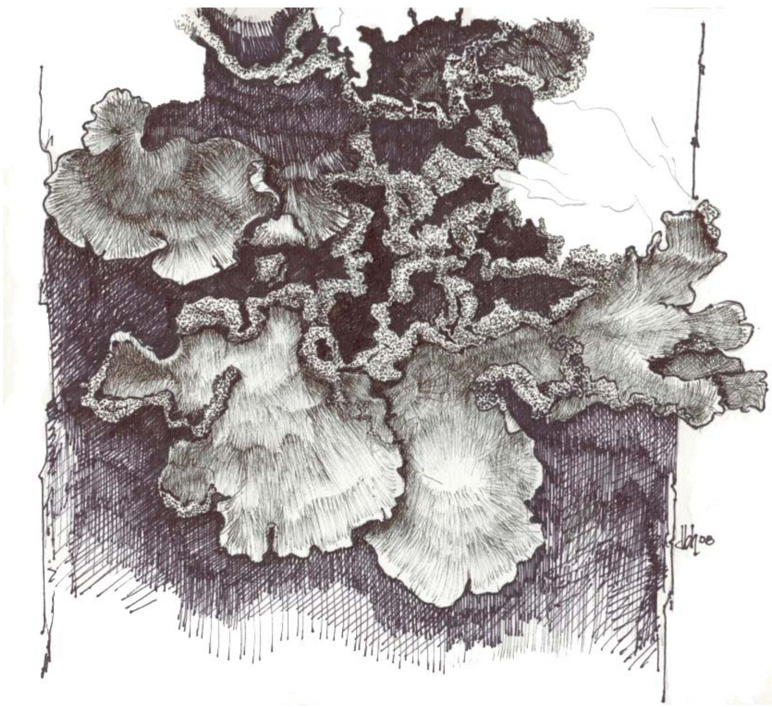
COSEWIC
Assessment and Status Report

on the

Vole Ears
Erioderma mollissimum

in Canada



ENDANGERED
2009

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC
Assessment Summary

Assessment Summary – November 2009

Common name
Vole Ears

Scientific name
Erioderma mollissimum

Status
Endangered

Reason for designation
This large foliose lichen is known in Canada only from Nova Scotia, New Brunswick, and the island of Newfoundland, where it inhabits cool, humid and coastal conifer forests dominated by Balsam Fir. Although there are 24 known sites for the lichen in these regions, few individuals (133 thalli) are known. While recent surveys have increased the number of known locations, the lichen has been extirpated from 11 sites in the last 30 years. This lichen is a sensitive indicator of air pollution and acid precipitation, which are its main threats. Other threats include forest harvest and browsing by moose.

Occurrence
New Brunswick, Nova Scotia, Newfoundland and Labrador

Status history
Designated Endangered in November 2009.

COSEWIC
Executive Summary

Vole Ears
Erioderma mollissimum

Wildlife species description and significance

Erioderma mollissimum is a foliose macrolichen with a felty, grey-brown upper surface. When wetted, it turns grey-green. The thallus is up to 12 cm broad and is comprised of radiating, loosely attached lobes to 1 cm in width. The lower surface lacks a cortex (outer protective layer), and except near the pale, bare margins is densely hairy and light-brown. Granular, bluish soredia (asexual propagules) are produced along the lobe margins and may also form in tiny patches on the upper surface of older lobes. The photosynthetic component of this lichen has been identified as *Scytonema*, a cyanobacterium that is rare in lichens occurring north of subtropical regions.

E. mollissimum is part of a group of rare cyanolichens found only in humid coastal forests of eastern North America. The Canadian populations of *E. mollissimum* are disjunct from other populations in the world which have a mainly tropical/subtropical distribution. The group of cyanolichens to which *E. mollissimum* belongs are useful indicators of effects of acid precipitation and air pollution.

Distribution

Erioderma mollissimum occurs mainly in montane tropical and subtropical cloud forests. Most of its known occurrences are in Central and South America, at elevations of 1600 to 3400 m. It occurs disjunctly in eastern North America, coastal southwestern Europe, and east Africa. In North America, it is known only in the Great Smoky Mountains (Tennessee and North Carolina), and in foggy, coastal areas of Atlantic Canada.

Habitat

In Canada, *Erioderma mollissimum* occurs in cool, humid coastal coniferous forests dominated by Balsam Fir. Cool summers, relatively warm winters and high rainfall are characteristics of these forests. Peatland density is high in the coastal forests and *E. mollissimum* is often found close to these wetlands. *E. mollissimum* is found on trunks of Balsam Fir on the island of Newfoundland and on Balsam Fir, Red Maple and Yellow Birch in Nova Scotia. In New Brunswick, one thallus was found on moss-covered rock.

Biology

E. mollissimum is part of a group of lichens known as cyanolichens. Species of this group consist of a fungal partner and a cyanobacterium, which photosynthesizes and fixes atmospheric nitrogen. Apothecia (sexual reproductive structures containing ascospores) are extremely rare in North America. Reproduction is either through fragmentation or specialized structures called soredia. Lichen soredia are larger than ascospores and this limits dispersal. Dispersal is likely not more than hundreds of metres for *E. mollissimum*. Fragmentation provides dispersal, but only on the same host tree as the parent thalli. However, it may play a role in long-term persistence within sites. *E. mollissimum* requires a very humid environment to thrive and is sensitive to acid rain and other air pollutants.

Population sizes and trends

There are only 133 documented adult and 50 juvenile *E. mollissimum* in Canada. Nova Scotia has the largest known population with 118 adults and 23 juveniles at 20 occurrences. On the Avalon Peninsula of Newfoundland there are 4 known occurrences with 15 adults and 27 juveniles. There is evidence to suggest a possible decline in population, particularly in Nova Scotia. At least 80% of sites in Nova Scotia known from the early 1980s no longer support *E. mollissimum*. Occupancy rates of habitat patches also appeared to have declined in Nova Scotia. *E. mollissimum* is most likely extirpated from New Brunswick.

Threats and limiting factors

Like other cyanolichens, *E. mollissimum* is extremely sensitive to air pollution and acid rain. Although acidifying pollutants in eastern North America are predicted to decline in the next 12 years, proposed developments in Newfoundland, New Brunswick and Nova Scotia may locally increase pollutants. Logging may limit available habitat and loss of forests from other developments is also occurring. Decreases in frequency of fog and herbivory by introduced slugs may also be a threat.

Protection, status, and ranks

E. mollissimum is not currently listed under SARA nor is it protected by provincial legislation. It has been assigned a red status (known or thought to be at risk) by the Province of Nova Scotia, S1 by the Atlantic Canada Conservation Data Centre and has a G-rank of 4/5. There is only one occurrence at the present time, that at Thomas Raddall Provincial Park, Nova Scotia, where *E. mollissimum* is within a fully protected area. The occurrences near Blandford, Webber Lake and Dooks Pond, NS may, however, receive protection in the near future. All the occurrences in Newfoundland are on crown land but have no legal protection.

TECHNICAL SUMMARY

Erioderma mollissimum
Vole Ears Érioderme mou
Range of occurrence in Canada (province/territory/ocean): NB, NS, NL

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	Uncertain, but may be 10 to 30 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown, but not likely

Extent and Occupancy Information

Estimated extent of occurrence	24,800 km²
Index of area of occupancy (IAO) based on 2x2 Km grids	88 km²
Is the total population severely fragmented?	Yes
Number of "locations∗"	Unknown - 24 sites are known, but many (an unknown number) could be affected simultaneously by a single threat (air pollution)
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Decline - no longer known to occur in NB
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Some decline, loss of southwestern NB
Is there an [observed, inferred, or projected] continuing decline in number of locations?	NS: 9 of 11 occurrences found in 1970s and 1980s no longer extant; NB: 2 occurrences no longer extant; NL: uncertain ca 20 new occurrences found since 2005

∗ See definition of location.

Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Loss of habitat from logging and possibly development in NL; Decline in habitat quality from acid rain and pollution particularly in NS and NB
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Southwestern NB – one occurrence (extirpated)	
Upper Bay of Fundy – two occurrences (Fundy, NB and Chignecto,	Unknown
NS; both thought to be extirpated)	
Southwestern NS – 16 occurrences (2 extirpated) – 87 adults	87
Easternshore NS – 12 occurrences (6 extirpated, 1 unknown) – 31 adults	31
Avalon Peninsula NL – 4 occurrences – 15 adults	15
Total	133
Model suggests as many as 4017 ± 2687 thalli could occur in NS but this could be considerably over-estimated	

Quantitative Analysis

Probability of extinction in the wild	N/A

Threats (actual or imminent, to populations or habitats)

Acid precipitation, air pollution, logging, development and possibly grazing from an introduced gastropod and decline in fog frequency.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? US: Great Smoky Mtns (Tenn, NC)	
Is immigration known or possible?	Very unlikely
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (2009)

∗ See definition of location.

Status and Reasons for Designation

Status: ENDANGERED	**Alpha-numeric code:** C2a(i)
Reasons for designation: This large foliose lichen is known in Canada only from Nova Scotia, New Brunswick, and the island of Newfoundland, where it inhabits cool, humid and coastal conifer forests dominated by Balsam Fir. Although there are 24 known sites for the lichen in these regions, few individuals (133 thalli) are known. While recent surveys have increased the number of known locations, the lichen has been extirpated from 11 sites in the last 30 years. This lichen is a sensitive indicator of air pollution and acid precipitation, which are its main threats. Other threats include forest harvest and browsing by moose.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion – no data on decline.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion since there is no evidence that the population is severely fragmented.
Criterion C (Small and Declining Number of Mature Individuals): Meets criterion C for Endangered (< 2500 individuals, using the known count, or using minimum model estimate) and C2, continuing decline with a(i) no population estimated to contain > 250 individuals.
Criterion D (Very Small or Restricted Total Population): Does not meet Endangered (D1 or D2) using the estimates (1470, Nova Scotia) from the habitat model.
Criterion E (Quantitative Analysis): Not done – no data.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2009)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Erioderma mollissimum (Samp.) Du Rietz
Botaniska Notiser 1926: 340 (1926)

Basionym: *Lobaria mollissima* Samp., Liquenes inéditos: 7 (1920).Type: Portugal, Minho, Sierra do Gerês, Castello Lanhoso, G. Sampaio s.n. (Lich. Exs. 226, UPS, lectotype designated by Jørgensen 2000).

Additional synonyms: *Erioderma limbatum* (Nyl.) Vainio (Jørgensen 2001)

Classification: Lichen names apply formally only to their fungal components, but by convention serve as a short-hand for the symbiosis involving both the fungal and photosynthetic components. The photosynthetic partners of *Erioderma* species are cyanobacteria which have been identified as belonging to the genus *Scytonema*. The specific identity of the *Scytonema* lichenized with *E. mollissimum* has not been resolved. Indeed a recent study suggests that the cyanobacteria from lichens hitherto ascribed to this genus do not cluster with *Scytonema* but belong to a highly diverse related undescribed lineage for which the name *Rhizonema* could be given. These highly efficient strains appear to have evolved through being shared by unrelated lichenized fungi with similar ecological requirements (Lucking *et al.* 2009).

The genus *Erioderma* includes about 25 species, with centres of diversity in South America and southeast Asia (Jørgensen 2000). *Erioderma mollissimum* is one of eight vegetatively reproducing (sorediate) species currently recognized in the genus (Jørgensen & Arvidsson 2001). The only other sorediate species occurring in North America, *E. sorediatum* D. J. Galloway & P. M. Jørg., is known on this continent only from Oregon to Alaska on the west coast, and in the Caribbean region. These two *Erioderma* species are clearly distinguished by morphological and chemical characters. *Erioderma* is classified in the family Pannariaceae, order Peltigerales, class Lecanoromycetes, and division Ascomycota (Ekman & Jørgensen 2002; Miadlikowska *et al.* 2006).

Jørgensen (2001) and Jørgensen & Arvidsson (2001) suggested that the then-known eastern North American sorediate *Erioderma* collections might not belong to *E. mollissimum*: "It has been impossible to make a final decision on their status, since the material is so scarce or badly developed, but I strongly suspect that they may represent a distinct taxon belonging to a different ecogeographic element" (Jørgensen 2000, p. 673). The identity of this material has recently been settled. Much better-developed thalli were discovered in Newfoundland in 2006, and lobes from two of these were examined morphologically and chemically. These and other subsequently discovered thalli from Nova Scotia and Newfoundland prove to be typical *E. mollissimum* (P. M. Jørgensen, personal communication).

Common name: The name “Vole Ears”, suggested to us by our Newfoundland colleague Mac Pitcher, is proposed here. This would be a counterpart to the name “Mouse Ears” adopted for *E. sorediatum* by Brodo *et al.* (2001). The proposed French common name is "érioderme mou" and "érioderme gracieux" has also been used (Fournier, 2006). The other proposed common name for *Erioderma mollissimum* is the “Graceful Felt Lichen”. To date there is no widely accepted list of common names for lichens.

Morphological description

Erioderma mollissimum is a foliose macrolichen growing up to 12 cms in diameter (Figure 1). Lobes can be up to one cm broad, ascending and loosely attached to the substrate. The colour of the thallus is grey brown when dry and grey green when damp. A distinctive tomentum (covering of fine hairs) occurs on the upper lobe surface. Often the hairs are erect near the lobe margin which has a tendency to be revolute. The lower surface is non-corticate (no protective outer layer) and white-fibrous and, except for a narrow band at the margin edge, has a dense tomentum of light brown rhizohyphae (extension of the lower surface). Bluish granular soredia are produced along the lobe margins in older parts of the thallus and sometimes occur at breaks in the laminal (upper) surface. Apothecia are extremely rare and have been found in only one occurrence in the Canadian populations. Fragmentation may occur in older, mature thalli which form reproductive structures, either soredia or apothecia.

Figure 1. Thallus of *Erioderma mollissimum* on trunk of *Acer rubrum* at Blandford, Nova Scotia. Photograph by Robert Cameron.

In the literature, there are no reported reactions when tissue of this lichen is spot tested with chemical reagents.

Genetic description

There are no published studies on the genetic relationships of *E. mollissimum* within *Erioderma* or at the population level. A major molecular phylogenetic study of the Lecanoromycetes, the class including the majority of lichen-forming fungi, demonstrated clearly that *Erioderma* is a member of the Pannariaceae (Miadlikowska *et al.* 2006). *Erioderma* was represented in this phylogeny by *E. verruculosum* (Vain.) Hue. Molecular studies of the photobionts of *E. pedicellatum* and other *Scytonema*-containing lichens in Newfoundland are currently in progress (C. Scheidegger, personal communication).

Designatable units

One designatable unit is recognized for the purpose of this assessment. Although the lichen occurs in two ecozones, there is no evidence of morphological, genetic, or other differences that support more than one designatable unit.

Special significance

E. mollissimum is part of a group of rare cyanolichens found in the humid coastal forests of eastern North America (Cameron and Richardson 2006, Cameron and Neily 2008). The Canadian populations of *E. mollissimum* are disjunct from other populations in the world which have a mainly tropical/subtropical distribution. Furthermore, the group of cyanolichens to which *E. mollissimum* belongs are useful indicators of acid precipitation and air pollution (Cameron *et al.* 2007).

DISTRIBUTION

Global range

Erioderma mollissimum has a highly disjunct global range (Figure 2). It occurs mainly in montane tropical and subtropical cloud forests. Most of its known occurrences are in Central and South America, where it has been recorded at elevations ranging from 1600 to 3400 m in the Dominican Republic, Mexico, Costa Rica, Venezuela, Colombia, Ecuador, and Brazil (Jørgensen & Arvidsson 2001). It occurs more rarely on the eastern side of the Atlantic Ocean, in Portugal, Spain, the Azores, and the Canary Islands, where it is confined to oceanic, montane sites. A widely disjunct population is known in the mountains of Kenya in east Africa. In North America, *E. mollissimum* is also strikingly disjunct in two areas far removed from one another, and from subtropical populations: the Great Smoky Mountains of Tennessee and North Carolina, and the hemiboreal to boreal coastal region of Atlantic Canada. In the Smokies, the four known occurrences are at elevations of c. 800 to 1800 m (Maass 1983). In Atlantic Canada, all of the occurrences are at less than 100 m.

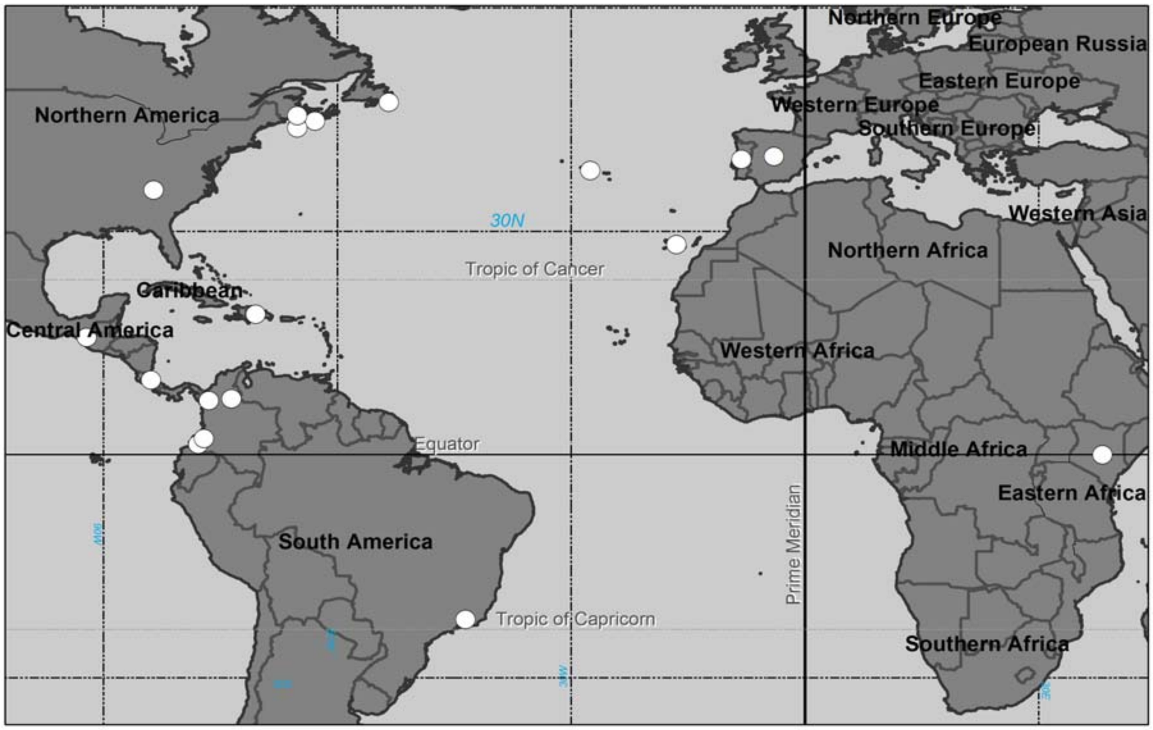

Figure 2. Global distribution of *Erioderma mollissimum.*

Canadian range

E. mollissimum is known from New Brunswick, Nova Scotia and Newfoundland and Labrador (Table 1, Figure 3). It was first identified in Canada (Jørgensen 1972) from a fragment of this species with the specimen of *E. pedicellatum,* from its type location at Campobello Island, New Brunswick. It was later found in that province's Fundy National Park, and subsequently in Nova Scotia (Maass 1983). Recent field research on *E. pedicellatum* has resulted in the further discovery of *E. mollissimum*, which is now known from 20 occurrences along the Atlantic Coast of Nova Scotia. *E. mollissimum* was first discovered in Newfoundland on October 6, 2006, at a field site on the Avalon Peninsula. Since then further discoveries have been made and to date *E. mollissimum* has been verified at four sites on the Avalon Penninsula. A recent report from Bay d'Espoir area, Newfoundland, has not been verified and is not included as an occurrence in this report.

Table 1. Canadian occurrences of *Erioderma mollissimum*. An occurrence is a place where trees are occupied by *E. mollissimum. To be a separate occurrence the colonized trees must be* greater than 0.5 km apart. Adults are thalli with reproductive structures, either soredia or apothecia. Juveniles are thalli lacking reproductive structures.

Population	Province	Occurrence	Year of discovery	Most recent survey	Number of juveniles	Number of adults
Southwest NB	NB	Campobello Island	1902	2005	0	0
Upper Bay of Fundy	NB	Fundy National Park	1980	2008	0	0
	NS	Cape Chignecto	1991	2003	0	0
South shore NS	NS	Lake John Road1&2	2007	2007	2	22
	NS	Lake John Road3	2007	2007	0	6
	NS	Clyde River Road1	2008	2008	0	1
	NS	Clyde River Road2	2008	2008	0	1
	NS	Martin Brook	2008	2008	0	1
	NS	Canada Hill1	2008	2008	0	7
	NS	Canada Hill2	2008	2008	0	1
	NS	Bon Mature Lake	2008	2008	0	1
	NS	Blandford	2006	2007	0	4
	NS	Robarts Pond	2008	2008	0	1
	NS	Jones Harbour	2008	2008	0	2
	NS	Thomas Raddall	1980	2008	11	32
	NS	Port L’Hebert	2008	2008	1	1
	NS	Mud Lake Creek	1981	1999	0	0
	NS	Glenwood	1981	2008	0	0
	NS	Haley Lake	1981	2008	0	7
Eastern shore NS	NS	Fuller Lake	2006	2007	8	8
	NS	Bear Lake	2006	2007	0	2
	NS	Otter Pond	2006	2007	1	6
	NS	Dooks Pond	2005	2007	0	4
	NS	Webber Lake	2007	2007	0	7
	NS	Beech Hill	1980	1980	0	4
	NS	Clam Harbour	1979	1998	0	0
	NS	Eisan Lake Road	1981	1998	0	0
	NS	Tangier Ferry	1982	1999	0	0
	NS	Marinette	1983	1985	0	0
	NS	Lochabor Mines	1981	1984	0	0
	NS	New Chester	1982	1998	0	0
NL - Avalon	NL	Hall’s Gullies1	2006	2007	8	3
	NL	Hall’s Gullies2	2007	2007	3	7
	NL	Hall’s Gullies3	2007	2007	16	3
	NL	SE Placentia	2007	2007	0	2

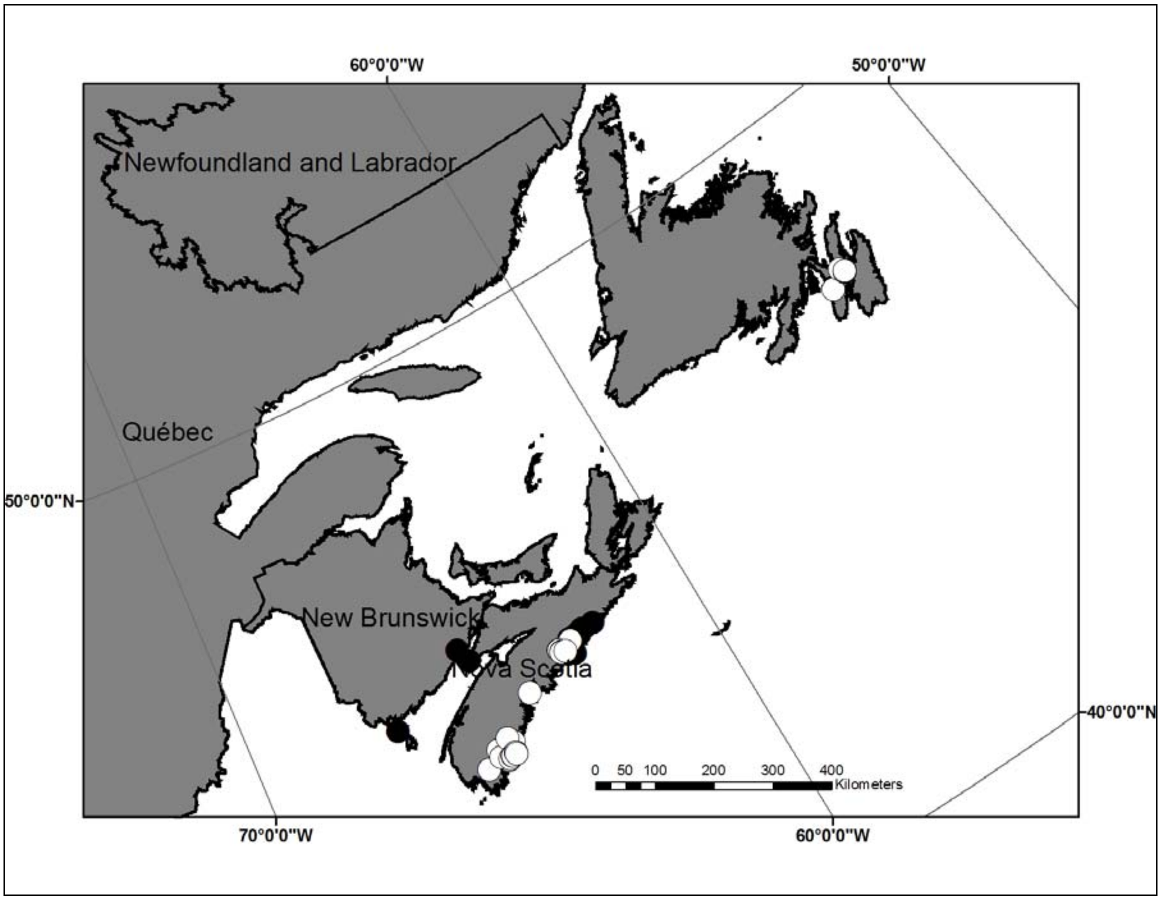

Figure 3. Current and historical Canadian distribution of *Erioderma mollissimum*. White circles indicate current known occurrences, black circles indicate historical occurrences.

The extent of occurrence in Canada using all sites from Nova Scotia and Newfoundland is 24,800 km^2 but this includes areas of unsuitable habitat. If the extent of occurrence is computed based on each colonized area then a more accurate figure may be 5195 km^2 for Nova Scotia and 21 km^2 for Newfoundland and Labrador. Extent of occurrence was estimated using Geographical Information System (GIS). The area of occupancy is 88 km^2 comprised of four grids in Newfoundland (16 km^2) and 18 grids in Nova Scotia (72 km^2).

A predicted distribution model was developed for *E. mollissimum* for Eastern Canada using a GIS-based Mahalanobis distance statistic. A variety of statistical modelling techniques with a GIS have been used to predict the distribution of species over large areas. The Mahalanobis distance statistic has been used to model distribution of animals (Barker *et al.* 2006) and plants (DeVries 2005). The advantage of the D statistic is that it can be applied using presence-only data and is robust enough for use with non-normally distributed data (Knick and Rotenberry 1998 in Roberts 2000). It is a dimensionless measure of the distance in multivariate space from one point to another (Roberts 2000). The model describes basic environmental requirements of a species based on the assumption that less variable environmental parameters in a species range of distribution are most likely to be associated with limiting factors. In other words, if a species lives under a wider variety of environmental conditions, it is less likely to encounter factors that limit its distribution than if it required less variable environmental conditions and thus had more restrictive requirements. Environmental variables that show a wide variation across the distribution range are considered less likely to limit a species distribution (Rotenberry *et al.* 2006).

Thirty-year climate normals from eight climate stations close to *E. mollissimum* sites in Atlantic Canada were used (Environment Canada 2000). To remove multicolinearity of climate data, a cluster analysis of the correlation matrix was done and only one variable was selected for variables with a high similarity. Data for total annual precipitation, rainfall, mean January temperature and mean December temperate were used in the model. Elevation data from Natural Resources Canada and distance from the coast were also used in the model. The model provides likelihoods of all areas in Atlantic Canada, including areas of known occurrence of *E. mollissimum* that were used in developing the model. Thus a type of self test is built in the model process to provide a rough validation check. However, for mapping purposes, any data points within predicted distribution were used.

The distribution model suggests that only a portion of the east coast of Canada has conditions suitable for *E. mollissimum*. The model predicted 2,722,441 ha of forest in Nova Scotia as possible area of distribution for *E. mollissimum* (Figure 4). Areas where *E. mollissimum* has not been specifically searched for within the area the model predicts include North Mountain, coastal forests of the Minas Basin and a few areas along the Northhumberland Strait. Much of the predicted area has been inventoried for lichens.

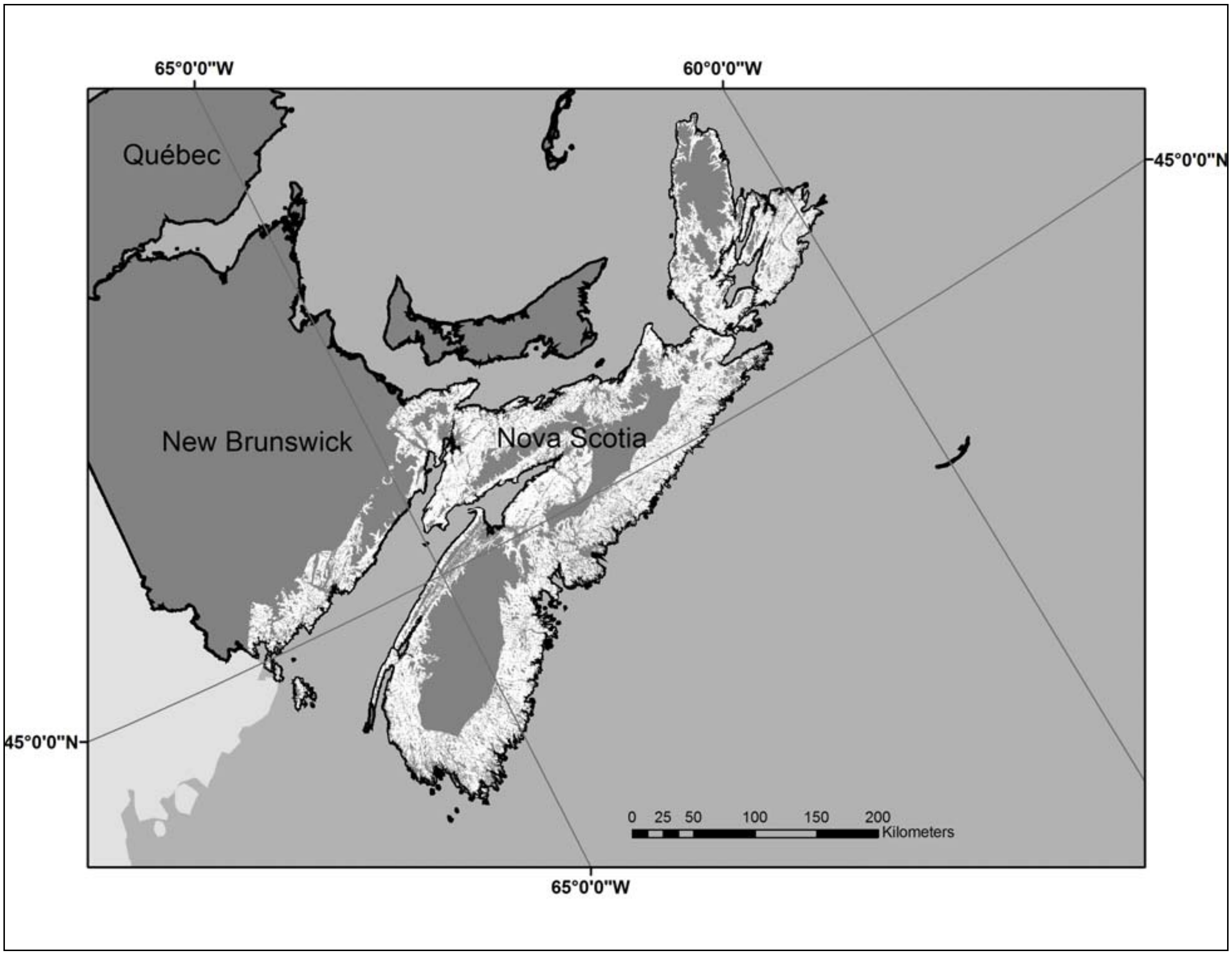

Figure 4. Predicted distribution of *Erioderma mollissimum* in Maritime Canada.

In New Brunswick the model predicted 451,037 ha of forest, mostly along the Bay of Fundy, as possible area of distribution for *E. mollissimum.* Much of this area has already been explored by lichenologists.

For Newfoundland and Labrador, the model identified 7 major areas: the Avalon Peninsula, Bay De L'Eau, Bay D'Espoir, Codroy Valley, Port Au Port Bay, Bay of Islands and Gros Morne (Figure 5). GIS-Forest cover data suggest there is 161,868 ha of forest in the Avalon. Area of forest could not be calculated for other areas of Newfoundland because of errors in forest cover data; however, there is a total of 215,813 ha in the area of distribution predicted by the model. Much of the new area identified by the model has had little lichen inventory work.

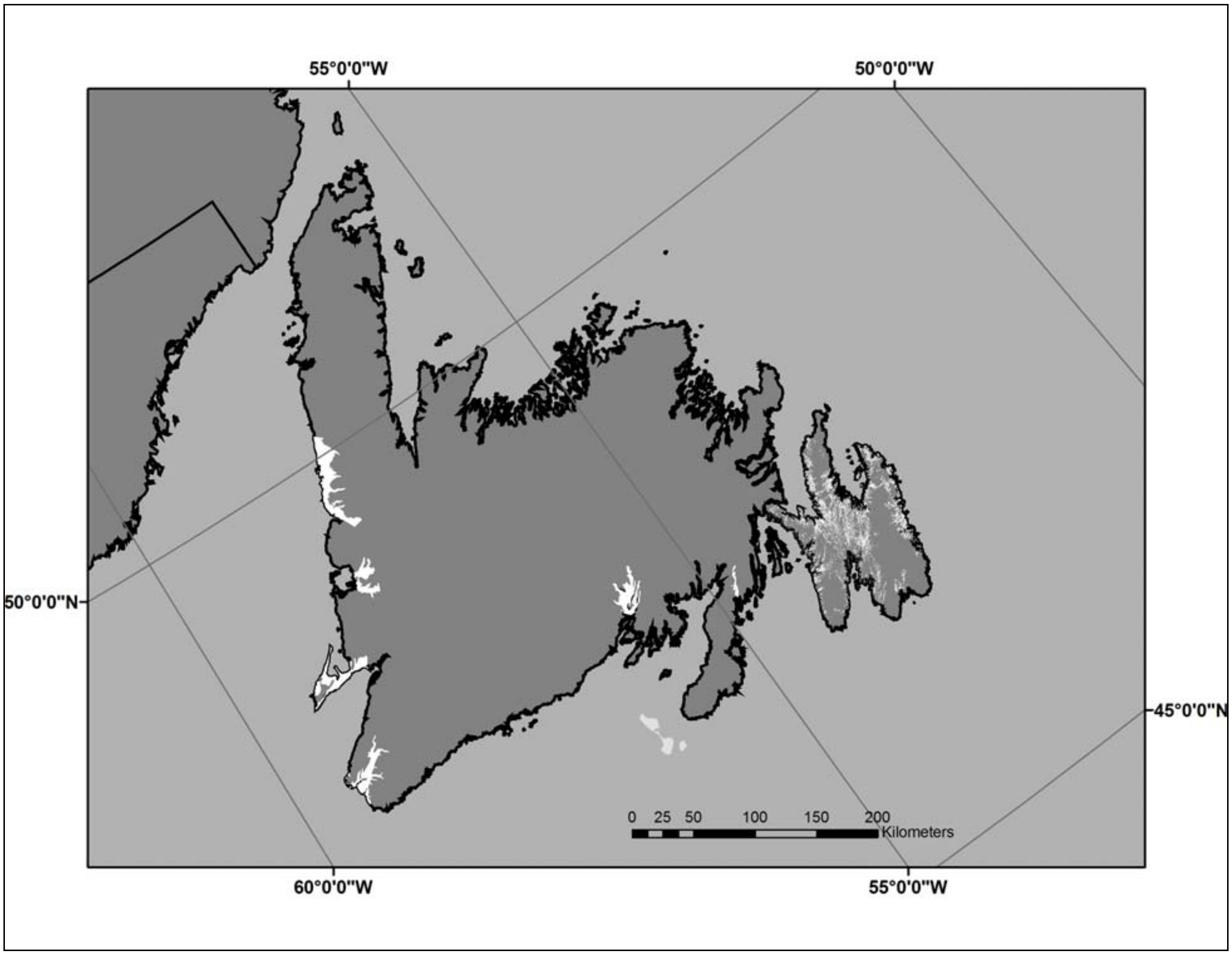

Figure 5. Predicted distribution of *Erioderma mollissimum* in Newfoundland and Labrador.

The distribution model predicts geographic areas where *E. mollissimum* is likely to occur given climatic parameters. The model does not predict likely habitat or amount of habitat and therefore does not include any habitat parameters such as forest type, slope or substrate. The model should only be used as a guide for future surveys as it has not been fully validated or tested, although it proved of great value for surveys carried out in Nova Scotia (see Figure 6). Because there are more known occurrences of *E. mollissimum* in Nova Scotia, the model is weighted for this province and may not work well elsewhere. It is not a habitat model, and does not include habitat parameters, so *E. mollissimum* will not be found in predicted areas if no suitable habitat occurs there.

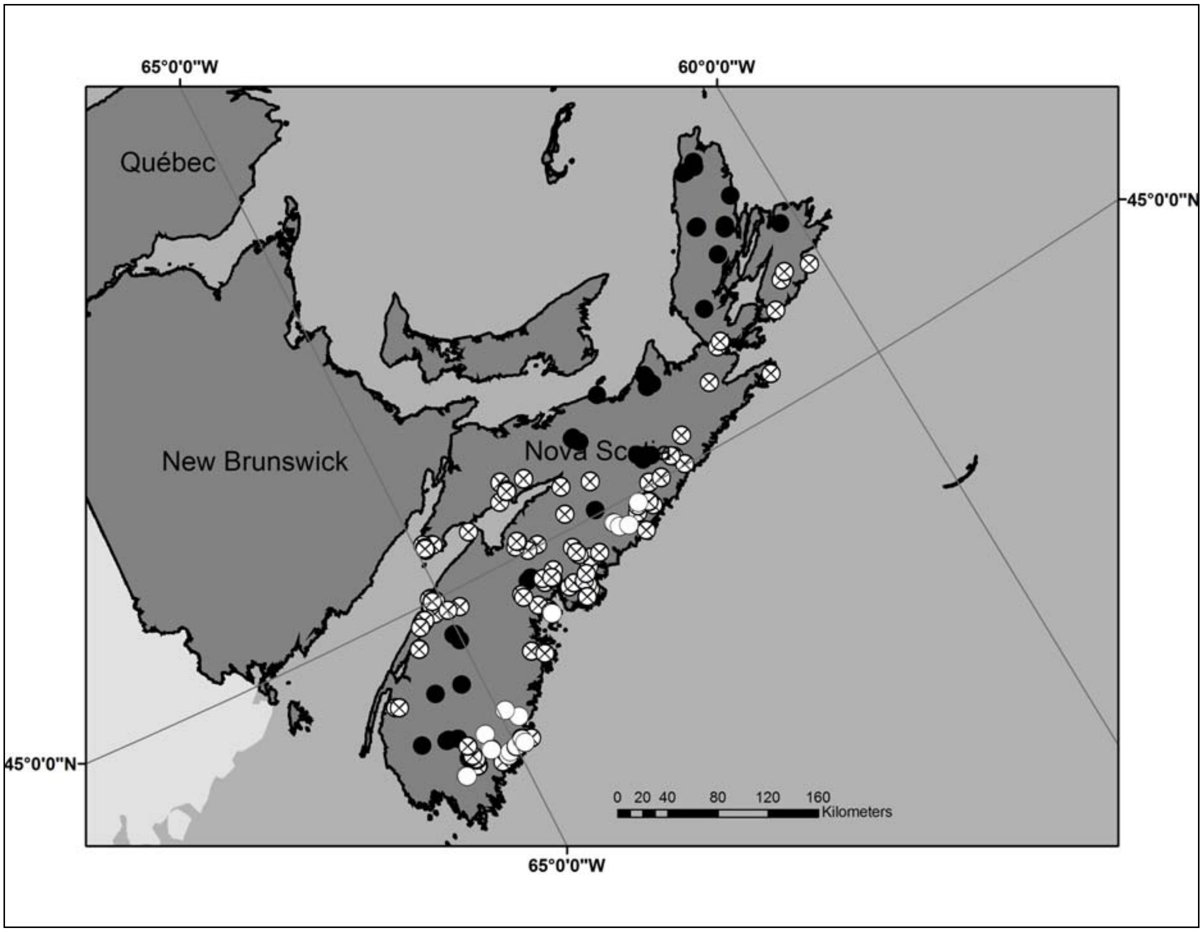

Figure 6. The search effort for *Erioderma mollissimum* in Nova Scotia between 1980 and 2008. The white circles indicate occurrences where *E. mollissimum* has been found within areas identified by the prediction model. The white circles with a X indicate indicate areas, identified by the prediction model, that have been searched but where *E. mollissimum* has not been found. The Black circles are searched sites in areas that fell outside those identified by the prediction. Note the fact that *E. mollissimum was not found at any of the black circle sites substantiates the value of the model for identifying areas* where lichen surveys for *E. mollissimum* could usefully be conducted.

Search effort

The search effort in Nova Scotia for *E. mollissimum* has been well documented for the last 4 years (2004 to 2008; Figure 6). A systematic survey for *Erioderma pedicellatum* and other cyanolichens was intitated in 2004. A predictive habitat model was developed for *Erioderma pedicellatum* and GIS used to map the habitats in Nova Scotia (Cameron and Neily 2008). The habitat model identified 13,852 patches of potential habitat scattered along the Atlantic coast. Patches were then searched for presence of *Erioderma pedicellatum* and other cyanolichens (Cameron and Neily 2008). Seventeen of the twenty verified *E. mollissimum* occurrences in Nova Scotia are a result of these surveys. A total of 289 of the 13,852 patches have been surveyed, representing about 867 hours of search effort.

Other studies in Nova Scotia have also contributed to the search effort for *E. mollissimum*. Maass (1983, 2000) surveyed a large number of areas for *Erioderma pedicellatum* and other cyanolichens. Search effort was not recorded. However, given that 46 occurrences with *E. pedicellatum* were recorded, the search effort must have been very high. Cameron and Richardson (2006) surveyed 14 protected areas in Nova Scotia for cyanolichens. Other lichen richness surveys in Nova Scotia include Casselman and Hill (1995), Seaward *et al.* (1997), Sneddon (1998), Selva (1999), Cameron *et al.* (2007) and McMullin (2007) as well as 2 Tuckerman workshops (1998 and 2004). Search sites of cyanolichens for Nova Scotia were assembled in 2006 as part of the cyanolichen status assessment for the province (Figure 6) (Anderson 2007). Two hundred and forty-eight sites have had extensive searches (not including the *E. pedicellatum* described in the paragraph above). Of those, 207 sites were within the predicted distribution area for *E. mollissimum.*

Search effort in Newfoundland is more difficult to quantify. *E. mollissimum* was first discovered in Newfoundland in 2006. Although there have been extensive surveys for *E. pedicellatum*, it is uncertain whether all surveys prior to 2006 would have detected *E. mollissimum*. However, extensive inventories in the 1980s and 1990s would likely have detected *E. mollissimum* had it been encountered, as Wolfgang Maass is familiar with the species. Maass (2000) reports 84 occurrences for *E. pedicellatum* and numerous other cyanolichens on the island of Newfoundland. The eminent lichenologist Dr. T. Ahti has also made several trips to the island of Newfoundland. A review of his collections and those by earlier collectors have not revealed any records of *E. mollissimum* (Ahti 1974, 1983). Conway has conducted about 600 hours of surveys for *E. pedicellatum* on the Avalon Peninsula, locating thousands of thalli. Digital photographs were taken of most thalli and these were recently re-examined to determine if any were *E. mollissimum*. Several possibilities were identified and the occurrences were re-visited in fall 2007, some of which were verified as *E. mollissimum*.

After the first identification of *E. mollissimum* in Newfoundland in 2006, local lichenologists have been looking for this species while conducting *E. pedicellatum* surveys. Search efforts have focused on Hall’s Gullies and Southeast Placentia resulting in three new verified *E. mollissimum* occurrences. The Newfoundland and Labrador Department of Natural Resources conducts surveys for *E. pedicellatum* on the Avalon Peninsula. The surveys conducted in 2007 included *E. mollissimum* and the search effort amounted to about 10 hours, mostly in the Hall’s Gullies area. The surveys totalled about 22 hours.

Many areas of potential occurrence along the Fundy coast of New Brunswick have been searched. Although the number of lichen vouchers for this area comprises at least 7,000 specimens, it is possible that some areas of potential habitat have yet to be explored.

HABITAT

Habitat requirements

Erioderma mollissimum occurs in humid forests. It is found in tropical rain forests in Brazil, Costa Rica and Dominican Republic. At higher latitudes *E. mollissimum* is found either in humid coastal forests as in eastern North America, Portugal or Spain or in montane habitats with heavy rainfall as in the Great Smoky Mountains.

In northeastern North America *E. mollissimum* is found within 30 km of the coast. When growing very near the coast it is found in forests of sheltered bays or inlets. Warm winters with a mean temperature of –4.5 ^{o}C and cool summers with a mean temperate of 16.4^{o}C, occur in these coastal forests. Precipitation is high, exceeding 1400 mm annually in many sites. Much of the precipitation falls as rain, averaging 88% of total precipitation for all sites. Fog frequency is also high in these coastal forests (Davis and Browne 1996). *E. mollissimum* is limited to elevations of less than 200 m in Atlantic Canada.

The Nova Scotia and Newfoundland *E. mollissimum* habitats are both highly humid coastal forests. In other respects the habitats are different. In Newfoundland *E. mollissimum* habitat can be characterized as mature or uneven aged coniferous forest dominated by *Abies balsamea* (Balsam Fir) on gentle, well drained to imperfectly drained slopes. In Nova Scotia, *E. mollissimum* habitat is typically in poorly drained depressions with mature coniferous or mixed forests dominated by Balsam Fir and/or *Acer rubrum* (Red Maple), with a ground flora dominated by *Sphagnum* species.

E. mollissimum is found on a variety of substrata. In Newfoundland it has been found only on Balsam Fir, while it in Nova Scotia it occurs on this tree species as well as Red Maple and *Betula alleghaniensis* (Yellow Birch). In New Brunswick one thallus was found on moss-covered rock.

<u>Newfoundland</u>

E. mollissimum occurs in Hall's Gullies and Southeast Placentia in Newfoundland. The two areas differ in surficial geology and topography but share similarities in forest type. Habitat for *E. mollissimum* is mature or uneven aged coniferous forests dominated by Balsam Fir on gently sloping terrain (2 to 10%), with a variable aspect and most often well drained soil. *E. mollissimum* can occur anywhere from lower, middle to upper slopes. Balsam Fir makes up at least 67% of all trees by basal area and in several cases exceeds 90%. Black spruce (*Picea mariana*) is the next largest component of tree species composition. Yellow birch and *Betula papyrifera* (white birch) are found occasionally. The proportion of dead trees in these forests is variable, ranging from 19% to 54%. Moss is abundant on the ground at all sites in Hall's Gullies and SE Placentia and there is usually little herb or shrub cover. *Sphagnum* species make up a large proportion of the moss cover. Peatland (bog or fen) density is very high, particularly in Hall's Gullies where *E. mollissimum* is never more than 80 m from one of these wetlands. The Southeast Placentia occurrence is about 500 m from a mapped wetland, however, small unmapped peatlands are found throughout this area.

The Hall's Gullies area, with four *E. mollissimum* occurrences, consists of a series of connecting ribbed moraines that are part of the Avalon Forest Ecoregion. The moraines can reach heights of 30 m and are more than 200 to 300 m apart. In between moraines are peatlands consisting of bogs and fens. Density of peatlands in this area is high, often occurring less than 100 m apart. The topographic pattern creates a mosaic of interspersed wetlands and forests, resulting in a highly humid habitat. Tree age from breast height cores average 73 years and indicate habitats at Hall's Gullies are more even-aged than Southeast Placentia. At Hall's Gullies crown closure averages 55% or more. Tree density can be high, e.g. >17,000 stems/ha at one Hall's Gullies occurrence to low, e.g. 3000 stems per ha.

The Southeast Placentia occurrence is in the Maritime Barrens Ecoregion, Southeastern Barrens subregion, characterized by large areas of exposed bedrock and heath barrens. Forests are limited to sheltered valleys and coves. Slope bogs, basin bogs and fens are common. *E. mollissimum* occurs on the south side (north facing) of a valley running east-west approximately 1 km wide and about 5 km long. The west end of the valley opens up to Placentia Bay. Northeast Arm is a short distance to the north and Southeast Arm is only a short distance to the south. Thus the valley is surrounded on three sides by large water bodies creating humid conditions. The Southeast Placentia occurrence appears to be an uneven aged forest with tree ages that range from regeneration (only a few years old) to cored trees at 180 years. Structure of the Southeast Placentia forest also differs from Hall's Gullies. Tree height and diameter at breast height are variable at Southeast Placentia because of the uneven aged structure. Sunlight has a much greater opportunity to reach *E. mollissimum* growing on tree boles at Southeast Placentia where crown closure is low (19%).

Nova Scotia

E. mollissimum in Nova Scotia is found on the Eastern Shore and the South Shore; both areas adjacent to the Atlantic Ocean. Bedrock is generally acidic and varies from granites to greywacke, slate and quartzite. Surficial geology on the Eastern Shore is variable with drumlins and stony till, while stony till dominates the South Shore. *E. mollissimum* occurs in 6 different Natural Landscapes of Nova Scotia. Natural Landscapes of Nova Scotia are an ecological land classification system consisting of 80 different landscape types across the province. Natural Landscapes with current *E. mollissimum* occurrences are all adjacent to and extend no more than 30 km from the Atlantic coast. The Eastern Shore landscapes can be described as gently rolling hills and drumlins interspersed with bogs and fens. Hills range in height from 30 to 50 m and are within 2 km of each other. The South Shore landscapes are less hilly with heights typically only 25 m high and distances between hills of 5 km. Larger bogs occur on the South Shore including dome and blanket bogs.

All *E. mollissimum* occurrences in Nova Scotia are in depressions and these are usually on level sites. The depressions occur occasionally on gentle slopes (<2%) with a north or northeast aspect; however, most sites are flat. Balsam Fir occurs in all habitats in Nova Scotia making up at least one third of the species composition. Red maple is a frequent species as is black spruce. Yellow birch is found occasionally making up less than 10% of the species composition. Dead trees are found at all occurrences and make up as much as 50% in several sites. Windthrow is a minor component at 3 sites. Mean tree age at breast height for all sites in Nova Scotia is 65 years but there is variation between sites (range 45 to 99 years) and within sites (e.g. range of 60 to 156 years at Blandford). Although the sites have a variety of tree age classes, they are not truly uneven aged as the young regenerating cohort is absent. Despite the maturity of trees, average tree height for all sites is only 8 m, reflecting the poor growing conditions. Forest structure is variable between occurrences but is more consistent within occurrences. For example, crown closure varies from 14% to 99% between occurrences while within occurrence variation is usually only about 25%. Tree density is also quite variable between occurrences, ranging from about 1300 to over 23,000 stems/ha. Shrubs occur at all occurrences covering between 3 and 25% of the ground. Herb cover is variable but can be as high as 80% at some occurrences. *Osmunda cinnamomea* (cinnamon fern) dominates the herb layer at all occurrences. *Sphagnum* species is present at all occurrences with a total ground cover of 70% or more at each location. Other species of moss are present in smaller amounts (5 to 15% of the ground cover).

Maass (1983) describes *Erioderma mollissimum* as occurring in *E. pedicellatum* habitat in Nova Scotia. However, our observations suggest that *E. mollissimum has* a slightly wider habitat tolerance than *E. pedicellatum* which may be related to its wider substratum preference. To date, on the Avalon Penninsula of Newfoundland, *E. mollissimum* occurs only in *E. pedicellatum* habitat.

A predictive habitat model for Nova Scotia suggests that the habitat for *Erioderma pedicellatum* is patchy (Cameron and Neily 2008). This model was developed by overlaying GIS layers of coast, forest cover and wetland. It identifies potential habitat as Balsam Fir stands within 30 km of the Atlantic coast and within 80 m of a peat wetland. The patchy distribution found for *E. pedicellatum* habitat seems also to apply to *E. mollissimum*. Density of the predicted patches is less than 1 habitat patch per 100 ha or about 16 ha per 100 ha. Forests in the Avalon Forest Ecoregion of Newfoundland are also patchy but with a density of about 35 forest stands per 100 ha and 37 ha per 100 ha. In the Maritime Barren Ecoregion of Newfoundland density is about 11 forest stands per 100 ha or about 16 ha per 100 ha. A limitation to the use of the *E. pedicellatum* habitat model for *E. mollissimum* is that it may not describe all types of habitat for *E. mollissimum*. However, Cameron *et al.* (2007) believe that *E. mollissimum* has only a slightly wider habitat tolerance than *E. pedicellatum* and therefore the difference in the amount and location of habitat is minimal. The value of this predictive model for identifying likely habitat for *E. mollissimum* was confirmed by successful surveys (see below under Search Effort and Table 6).

Microhabitat

In Newfoundland, *E. mollissimum* has only been found on the trunks of Balsam Fir. In Nova Scotia, *E. mollissimum* occurs on trunks of Balsam Fir, Yellow Birch and Red Maple. Height of the thalli on the trunk ranges from 0.8 m to almost 3 m. Orientation on the trunk varies but most thalli are on the northeast (25% of thalli), northwest (30% of thalli) or southeast (25% of thalli) side. All trees on which *E. mollissimum* has been found have been mature or old. Stand tree ages average 65 years in Nova Scotia and 73 years in Newfoundland. In both Newfoundland and Nova Scotia, *E. mollissimum* is found with a large number of lichen species that are common in these provinces including the genera *Hypogymnia, Parmelia, Bryoria, Cladonia* and *Platismatia*. Associates in Nova Scotia that are typical of humid coastal forests include *Alectoria sarmentosa, Pseudocyphellaria perpetua, Pannaria conoplea* and *Fuscopannaria ahlneri*. Rare or uncommon species found with *E. mollissimum* in Nova Scotia at the same habitat but not necessarily on the same tree include several cyanolichens. Two of the rare species are *Erioderma pedicellatum* and *Pannaria lurida.* Uncommon cyanolichen species frequently found with *E. mollissimum* are *Coccocarpia palmicola, Degelia plumbea, Leptogium laceroides, Lichinodium sirosiphoideum, Moelleropsis nebulosa* ssp. *frullaniae, Pannaria rubiginosa* and *Parmeliella parvula.* Rare or uncommon associates of *E. mollissimum* in Newfoundland include *Erioderma pedicellatum, Fuscopannaria ahlneri, Lichinodium sirosiphoideum,* and *Moelleropsis nebulosa* ssp. f*rullaniae.*

<u>Air quality</u>

One of the most critical habitat requirements for cyanolichens is the need for clean air (free of pollutants) and precipitation free of acidifying contaminants. The sensitivity of lichens to air pollution and acid rain has been well documented (see Henderson (2000) for a list of studies). The sensitivity of lichens to air quality reflects their reliance on airborne nutrients and water, as well as lack of protective structures such as cuticles found in vascular plants (Richardson & Cameron 2004). Cyanolichens are particularly sensitive to acid rain, sulphur dioxide and nitrogen oxides (Gilbert 1986, Hallingback 1989, Hawksworth and Rose 1970, Sigal and Johnston 1986). Cyanolichens are especially affected because nitrogen fixation, essential for their survival, is more sensitive to acid rain than photosynthesis (Gries 1996). Cameron *et al.* (2007) found cyanolichens more sensitive to pollution in Nova Scotia than most other groups of lichens and Maass and Yetman (2002) attribute decline in *Erioderma pedicellatum* in Atlantic Canada partially to acid rain and air pollution.

Habitat trends

Acid deposition is still affecting Atlantic Canada and thus may continue to reduce habitat quality for *E. mollissimum*. The 2004 Canadian Acid Deposition Science Assessment results indicate that even though total acid deposition has declined in eastern Canada, large areas continue to receive levels in excess of critical loads (Environment Canada 2004). Critical loads are defined as the level of acid deposition below which the ecosystem can assimilate without significant harmful effects. Critical loads are determined from soil, geology, vegetation type, climate and wind patterns. The Science Assessment presents a worst case and best case scenario depending on how much NOx deposition is considered to contribute to acid precipitation. Even in the best case scenario, southwestern Nova Scotia (where the largest known population of *E. mollissimum* occurs), and southwestern New Brunswick have the highest exceedances anywhere in Canada. The eastern shore of Nova Scotia also exceeds critical loads. The upper Bay of Fundy and Avalon Peninsula are below critical loads in the best case scenario but exceed critical loads in worst case scenarios. Exceedances are despite a 21% decline in SO_2 emissions and 17% decline in NOx emissions in eastern Canada between 1985 and 2000. More than 50% of nitrogen and sulphur deposition in Nova Scotia and southern New Brunswick are from the eastern US and southern Ontario and Quebec. Emissions of SO_2 in the US have declined 40% between 1985 and 2000 but there has been little decline in NOx.

Predicted declines of SO_2 and NOx in eastern Canada are 21% and 39% respectively between 2000 and 2020. In the US predicted declines are 38% for SO_2 and 47% for NOx by 2020. It is unknown how these declines will affect critical load exceedances.

Several developments in Newfoundland and one in Nova Scotia could affect future air quality near *E. mollissimum* occurrences despite expected reductions in overall pollution in eastern Canada and the US. The Newfoundland and Labrador Refining Corporation has proposed to build an oil refinery at Southern Head on Placentia Bay. The project is in the environmental assessment stage and expected to begin operation in 2011. The refinery will process 300,000 barrels of crude oil per day with a possibility of expanding to 600,000. The refinery will be about 60 km north of the nearest *E. mollissimum* occurrence in Southeast Placentia. Annual emissions for SO_2 and NOx are expected to be 6589 and 3228 tonnes respectively when processing 300,000 barrels per day. Annual emissions will double with expansion to 600,000 barrels (Environmental Assessment (EA) Report 2006a). Voisey's Bay Nickel is proposing a nickel processing plant in Long Harbour about 23 km north of the nearest *E. mollissimum* occurrence in Southeast Placentia. This project is also in the environmental assessment stage. Expected emissions range from 201 to 212 tonnes of SO_2 and 57 to 94 tonnes of NOx depending on the processing method (Environmental Assessment (EA) Report 2006b). A possible expansion of the Come by Chance Oil Refinery in Newfoundland could double the current processing of 115,000 barrels per day (Morgan 2008) and result in increased pollution emissions. It is unknown how much habitat deterioration will occur as a result of these developments.

In Nova Scotia a gold mining operation, which includes smelting, is proposed for Moose River, about 8 km northwest of the nearest *E. mollissimum* occurrence in Bear Lake. Emissions from the gold processing are expected to be 14 $\mu g\ m^{-3}$ SO_2 annually with peaks exceeding toxicity levels for some sensitive lichens (EA Report 2007). It is unknown how much habitat deterioration will occur as a result of this development.

Forestry operations are limiting available habitat for *E. mollissimum*. This is because *E. mollissimum* occurs in mature to overmature (age classes 60 years or greater) forests and these are the forests that are targeted by forestry. In Forest District 1, Avalon, Newfoundland, age class distribution indicates about 28% of the total forest area is in age class 61 to 80 and 23% in the 80+ age class. If harvest does not exceed the Annual Allowable Cut (AAC), age classes in 50 years are predicted to be 13% and 34% in the 61 to 80 and 80+ age class respectively (Anon. 2006). In Nova Scotia, the most current (updated 2006) age class distribution from forest cover data for areas within the predicted distribution area of *E. mollissimum* indicates that only about 6% of the forest is mature or overmature (>60 years of age). However, about 22% of the total forest area is classified as uneven aged and it is uncertain if this could provide suitable habitat. In New Brunswick, the most current (2003 & 2004) age class distribution from Forest Cover data for areas within the predicted distribution area of *E. mollissimum*, indicates that about 40% of Balsam Fir and spruce forest are in older age classes. About 32% of area of species other than spruce and fir are in mature or overmature age classes. Thus there is some habitat still available but it may be limited by high harvest levels.

One indication of the level of forest harvesting can be determined by comparing Annual Allowable Cut (AAC) and actual harvest level. Forest harvesting in Avalon Forest District 1, Nova Scotia and New Brunswick have all exceeded or been equal to AAC over a recent 10 year period (Anon. 2006, Natural Resources Canada).

Moose, a recent introduction to Newfoundland, are likely limiting the available habitat for *E. mollissimum* (see Threats and Limiting Factors for more detail).

Natural processes such as windthrow, wildfire, insect and disease also affect forests in ecoregions occupied by *E. mollissimum*. These processes interact with human effects and may limit current and future habitat availability.

BIOLOGY

Life cycle and reproduction

Erioderma mollissimum is part of a group known as cyanolichens, so named because one partner of the symbiosis is a cyanobacterium. The cyanobacterial partner in the case of *E. mollissimum* is in the genus *Scytonema*. The cyanobacteria provide carbohydrates through photosynthesis to the fungal partner and also fix atmospheric nitrogen. Moisture is important for nitrogen fixation and photosynthesis for cyanolichens (Nash 1996). These lichens require liquid water in order to be metabolically active and cannot photosynthesize using water accumulated from humid air as can green-algal lichens. This is why many species of cyanolichens are only found in very moist habitats such as coastal rain forests, fog forests and old growth forests. The cyanobacterium partner is also sensitive to acidification of the substratum as a result of air pollution or acid rain (Richardson and Cameron 2004).

E. mollissimum, like other foliose lichens, obtains nutrients through interception of aerosols, gaseous absorption and deposition from precipitation, fog or dew (Nash 1996).

Sexual reproductive structures (apothecia) are extremely rare in *E. mollissimum* and have only been found once in North America, on a thallus growing at Jones Harbour in southwest Nova Scotia*.* Reproduction is usually asexual via soredia or fragmentation. Soredia are small granules composed of fungal hyphae wrapped around cyanobacteria. Dispersal can be by wind, rain or animals. Fragmenting thalli were found in four occurrences (2 in NS, 2 in NL) of 12 occurrences where thallus measurements were taken (Table 2). As the thallus of *E. mollissimum* grows, the centre begins to break up, eventually dying. Outer lobes become detached from other lobes and may establish separate thalli. This process does not contribute to long distance dispersal but can locally repopulate a substrate from mature or dying thalli. However, not all thalli appear to reproduce this way. Many large, and presumably old, thalli at several occurrences in Canada have not fragmented.

Table 2. Number of known thalli by life stage and population for 12 occurrences. Life stage number is in brackets below life stage name. Life stage numbering is assuming an inconspicuous early life stage. Counts were done between 2006 and 2008.

Population	Unfragmented thalli			Fragmented thalli		
	Juvenile (2)	Pre-adult (3)	Adult (4)	Juvenile (5)	Pre-adult (6)	Adult (7)
South Shore NS	0	34	23	0	2	3
Eastern Shore NS	4	23	1	2	2	0
Avalon NL	0	6	0	16	8	0

Based on measurements of 124 thalli (Table 2) between 2006 and 2008 (Cameron, Neily, Clayden and Maass, unpublished data), there appear to be as many as 7 life stages for *E. mollissimum*. There may be an early stage of dormancy and colonization that is invisible to the naked eye as found in other foliose species (Hilmo and Ott 2002). This corresponds to stage 1 and such juvenile early growth stage is likely slow (Beschel 1958, Armstrong 1974, Hestmark *et al.* 2004). Stage 2 is when juveniles are visible and have diameters of less than 0.5 cm. The pre-adult stage 3, occurs between 0.6 cm and 10 cm. During this stage a thalli may lack soredia, may have emerging soredia or can have a few fully developed soredia. This pre-adult stage has been observed in other species of foliose lichen (Hestmark *et al.* 2004) and in other cyanolichens (Cameron and Garbary, unpublished data collected 2007 and 2008). At stage 4, thalli are greater than 10 cm diameter and have soredia but have not fragmented, and are thus classified as adults. Fragmentation, if it occurs, usually starts when the parent thallus is between 6 and 10 cm diameter. A senescence phase may follow. Growth stops and the thallus disintegrates (Armstrong 1974, Hestmark *et al.* 2004). Fragmentation may be part of this senescent phase in *E. mollissimum* and fragmented thalli may re-enter growth phase 2 or 3. When fragmentation occurs, the fragment is considered an individual because it appears to grow and reproduce as an individual. At stage 5, a fragment is small (<0.5 cm diameter) and is not sorediate and thus classified as a juvenile fragment. Stage 6 is when pre-adult fragments are between 0.5 and 2.0 cm diameter and 50% have soredia. In stage 7 fragments are greater than 2.0 cm and develop soredia.

Hestmark *et al.* (2004) found that slower growing species had more sexually sterile individuals in larger size classes and faster growing species had more reproductive individuals in smaller size classes. Although apothecia are rare in *E. mollissimum,* the pattern with soredia seems to be similar to the latter group. Thus once established at a location *E. mollissimum* may reach reproductive maturity relatively quickly.

A negative exponential distribution of size classes at a location (a large number of individuals in small-size classes and a fewer number of individuals in larger-size classes) may be an indication of either a stable or a growing population at the location (Armstrong 1988, Hestmark *et al.* 2004). The data collected between 2006 and 2008 reveal that of the 12 occurrences where thalli of *E. mollissimum* were measured, only Fuller Lake in Nova Scotia and Hall's Gullies 3 in Newfoundland show a distribution similar to the negative exponential. Because population numbers are so low at these sites it cannot be determined if they truly follow a negative exponential curve. All juveniles, except one, at Hall's Gullies 3 are derived from fragments and more than 60% of juveniles at Fuller Lake are derived from fragments. Fragmentation may thus be important in long-term persistence at an already established location, whereas soredia may be more important for dispersal and persistence in the landscape.

Otter Pond, NS, has a high frequency of adults in the smaller size classes. This may indicate that Otter Pond is a relatively newly established occurrence for *E. mollissimum*, with individuals only just becoming adults and not yet producing juveniles. Another explanation for the Otter Pond size class distribution is that growth is very slow at the location, thus the adults are old but small. This seems unlikely given the abundance of other cyanolichens at the occurrence.

All other occurrences have a distribution with higher frequencies in larger size classes most of which are adult. This means that these occurrences are recruiting few new individuals, either through soredia or fragmentation.

Herbivory/predation

Many groups of invertebrates are known to graze lichens including Thysanurans, Collembolans, Psocopterans, Lepidopteran larvae, oribatid mites and gastropods (Sharnoff and Rosetreter 1998). Of 96 *E. mollissimum* observed between 2006 and 2008, 12 (13%) showed evidence of grazing. Area of the thalli grazed ranged from 1 to 20%. Most grazing had patterns typical of small invertebrates such as oribatid mites or Collembola. Only 3 thalli had grazing patterns typical of gastropods (Sharnoff and Rosetreter 1998). Cameron (unpublished data collected between 2003 and 2008) found three species of gastropod typically feeding on cyanolichens in Nova Scotia. *Pallifera dorsalis* is a small native slug, and *Arion subfuscus* and *Deroceras reticulatum* are larger aggressive species introduced from Europe (Davis 1992). Cameron found all three species on the Eastern Shore of NS, feeding on several rare cyanolichens including *Erioderma pedicellatum* and *Coccocarpia palmicola*. Only 20% of arboreal slugs found were the native *P. dorsalis,* the remainder were mostly *A. subfuscus* (70%) and a few were *D. reticulatum.*

Physiology

There have been no published studies on the physiology of *E. mollissimum.* However, some inferences can be made based on its habitat requirements and geographic distribution. The proximity to the coast and to wetlands suggests a need for highly humid conditions, which is consistent with other cyanolichens. The fact that this lichen does not occur on trees with acidic bark like pine, spruce or white birch, suggest a sensitivity typical of most cyanolichens. Maass (2000) found that the outer bark of *E. mollissimum* phorophytes (Balsam Fir, Red Maple, Yellow Birch) was less acidic than other available substrata (spruce species). This may be part of the explanation as to why *E. mollissimum* is sensitive to pollutants capable of acidifying host tree bark.

Dispersal/migration

Wind, water and animals are the dispersal agents for *E. mollissimum*. As soredia typically disperse no more than a few hundred metres in forests, dispersal of *E. mollissimum* is likely limited (Richardson and Cameron 2004, Walser 2004), especially as spore-producing apothecia are extremely rare. Several studies have suggested that *Lobaria pulmonaria,* a sorediate lichen containing both green algae and cyanobacteria, is more limited by dispersal than habitat (Öckinger *et al.* 2005, Sillet *et al.* 2000). This may also be the case for *E. mollissimum*. Surveys of predicted *Erioderma pedicellatum* habitat patches in Nova Scotia showed that *E. mollissimum* occupies only 6% of the patches (see Habitat Requirements Nova Scotia for description of habitat patches). Predicted patch density is low in Nova Scotia with a mean distance between patches of 1.2 km. *E. mollissimum* may be limited in its ability to disperse between these patches in Nova Scotia.

Interspecific interactions

Of 96 thalli observed between 2006 and 2008, in Canada, 5 were being overgrown by other lichens. These included *Platismatia glauca, Parmelia sulcata, Pseudocyphellaria perpetua, Lobaria pulmonaria* and *L. quercizans*. Percentage of the *E. mollissimum* thallus covered ranged from 5 to 70%. Overgrown portions were dead or necrotic. Typically in Nova Scotia and Newfoundland, phorophytes of *E. mollissimum* have abundant epiphytes of lichens, liverworts and mosses.

Adaptability

Ability to persist for long periods in favourable habitats may be indicated by the long term presence (2 decades) of *E. mollissimum* at 2 occurrences in Nova Scotia. It is able to establish on a variety of substrates. Thus if one substrate becomes unavailable it may be able to establish and persist on other substrates.

E. mollissimum may not be well adapted to large scale or local level forest disturbances because of its requirement for very humid conditions. Local changes in forest structure can alter microclimates reducing local moisture regimes. For example loss of the single remaining thallus of *Erioderma pedicellatum* in Sweden is attributed to adjacent clearcutting (Purvis 2000). The need for highly humid conditions suggests that this lichen may not survive such disturbances. Large stand replacing disturbances are likely problematic for *E. mollissimum* because of its limited dispersal ability.

POPULATION SIZES AND TRENDS

Abundance

There are 183 thalli of *E. mollissimum* that have been verified (Cameron *et al.*, unpublished data) between 2006 and 2008. Of those 133 are adult and 50 are juvenile. Adults are thalli with soredia and/or apothecia. Fragments that appear to be separate from one another or the main thallus are considered individuals. Another two occurrences of *E. mollissimum* in the Hall's Gullies area of Newfoundland were discovered by E. Conway and later verified by C. Scheidegger in 2008. Nova Scotia has the most occurrences (20) and the greatest number of thalli (141). Newfoundland has 4 occurrences with 42 thalli. Differences in populations between NS and NL may be due, in part, to search effort. In New Brunswick, there have been extensive surveys for lichens along the Fundy coast searching for this lichen, *Degelia plumbea*, and other lichens but all have failed to discover *E. mollissimum*.

Most occurrences only have a few thalli, but where there are more thalli, they are only found on one or two trees. Occurrences with abundant thalli (e.g. Lake John Road2 and Hall's Gullies3) appear to be derived from fragments of a single parent thallus. Occurrences tend to be scattered across the landscape.

It is possible to estimate the total population of *E. mollissimum* in Nova Scotia using the *E. pedicellatum* habitat model, because *E. mollissimum* occurs in *E. pedicellatum* habitat. Two hundred and eighty-nine patches representing 2% of the 13,852 predicted habitat patches have been surveyed for *E. mollissimum* giving a population sample of 84 adults. This represents 0.29 adults per patch with a 95% confidence interval ±0.194. Estimation from the sample suggest a total population in Nova Scotia of 4017 adults (95% confidence interval 2687). Some caution is needed as confidence intervals are very high. Also, sampled sites were not selected randomly or systematically, *E. mollissimum* may occur in more habitats than *E. pedicellatum*.

Cameron and Neily (2008) found some inaccuracies in the forest typing of GIS layers used for the habitat model.

The population of *E. mollissimum* in Atlantic Canada appears to be severely fragmented. COSEWIC defines severe fragmentation as a population with small isolated subpopulations with increase extinction risk. IUCN (2008) severely fragmented criteria include populations where most (>50%) of the total area of occupancy is in habitat patches that are: 1. smaller than minimum viable population size; and 2. separated from other habitat patches by a large distance. All known subpopulations in Atlantic Canada are greater than 80 km apart which exceeds the minimum 50 km distance suggested by IUCN for non-spore producing species. Although *E. mollissimum*, can produce spores, it is very rare and the main dispersal mechanism is likely soredia or fragmentation. The *E. pedicellatum* habitat model suggests there are habitat patches occurring between the South Shore and Eastern Shore subpopulations. However, many of these patches have been surveyed and found unoccupied and are continually being isolated by human activities on the landscape (see LIMITING FACTORS AND THREATS). The size of minimum viable population for *E. mollissimum* has not been determined.

Fluctuations and trends

There is evidence to suggest *E. mollissimum* may be declining in Nova Scotia. Maass documented 12 occurrences in Nova Scotia between 1979 and 1982 (Maass 1983, Maass 1997 and Maass 2000). Of those 12, *E. mollissimum* could no longer be found at 9 occurrences when these were revisited between 1984 and 2008. One occurrence has not been revisited and only two occurrences still contain *E. mollissimum*. Maass (2000) attributes most of the decline to air pollution, with one occurrence loss from a porcupine and another attributed to microclimate change as a result of a nearby clearcut. The loss of *E. mollissimum* might also be attributed to natural population turnover and nearby habitat patches could have been colonized. Cameron *et al.* (2007) believe this is unlikely because extensive searches in patches adjacent to those previously occupied failed to reveal any new populations. Further it is known from two of Maass' early occurrences that *E. mollissimum* can persist at a location for more than twenty years. The decline over 10 years is calculated as 30%, using the above data. Nine of 11 sites are no longer extant over a 24 year period suggesting an annual decline rate of -3.4%. Decline rate of -3.4% compounded over 10 years is 30%.

Cameron *et al.* (2007) suspect that the time required to find *E. mollissimum* in the early 1980's in Nova Scotia may have been less than the current amount of time needed to find it. Maass identified 46 *E. pedicellatum* habitat patches in Nova Scotia that were searched for cyanolichens, 10 of which had *E. mollissimum.* This suggests that about 22% (10/46) of habitat patches were occupied by *E. mollissimum* in the early 1980s. Surveys of different habitat patches between 2004 and 2008 reveal that 18 of 289 patches surveyed are occupied by *E. mollissimum*. This indicates that only 6% of habitat patches are currently occupied by *E. mollissimum*. Some caution is needed in comparing occupancy rates of the two studies because the methods were dissimilar in several respects. Habitat patches were found by different methods and there may have been different search effort between the two study periods. Furthermore, the same habitat patches were not re-surveyed in the second study and habitat patches in both studies were selected subjectively. The decline over 10 years is calculated as 26.5%, using the occupancy data. Over a 24-year period, occupancy declined from 22% to 16% suggesting an annual decline rate of -3.0%. The decline rate of -3.0% compounded over 10 years is 27%.

No trend data are available for Newfoundland because the species has only been recently discovered. However, Goudie and Conway (2007) indicate that populations of *E. pedicellatum* at their study sites in Lockyer's Waters and Southeast Placentia are declining at a rate of 0.091 and 0.167 per year, respectively. Given *E. mollissimum* occupies the same habitat as *E. pedicellatum* in Newfoundland and is susceptible to many of the same threats and limiting factors, it is not unreasonable to assume that *E. mollissimum* is suffering the same decline as *E. pedicellatum*.

Only two occurrences were known for *E. mollissimum* in New Brunswick both of which no longer exist. The type locality was discovered in 1906 and has been searched periodically from the early 1980s to 2005 while the second site at Fundy National Park was re-visited in 2008. In spite of intensive searches, no thalli of *E. mollissimum* were found.

Rescue effect

The nearest population of *E. mollissimum* outside Canada is in the Great Smoky Mountains (Tennessee and North Carolina) about 1800 km southwest of the nearest Canadian occurrence. Rescue effect from the US population is very unlikely.

THREATS AND LIMITING FACTORS

Pollution

The cyanolichens, including *Erioderma mollissimum*, are extremely sensitive to air pollution and acid rain (Richardson & Cameron 2004). When the soluble pollutant gas sulphur dioxide (SO^2) dissolves, it forms undissociated sulphurous acid, bisulphite ions, or sulphite ions depending on the acidity of the solution. The sulphur in all these forms is highly reactive in living organisms. Sulphur dioxide when emitted at low elevations (e.g. from coal burning house chimneys or factories) can dissolve in water films on or within moist lichen thalli.

Dissolved sulphur dioxide is toxic to cyanolichens, including *Erioderma*, and is most toxic under acidic conditions. Sulphite is the least toxic to living organisms. Sensitive lichens such as the cyanolichens are better able to thrive on substrata with high pH when exposed to dissolved sulphur dioxide. Because high level emissions are not as common today as they were in the past, cyanolichens of Atlantic Canada are less affected by this form of pollution (Richardson 2008).

When sulphur dioxide is emitted from high chimney stacks it is often accompanied by nitrogen oxides resulting from the high temperature combustion of coal or oil. These compounds remain in the atmosphere for a relatively long time period before being washed out by rain. The sulphur dioxide becomes oxidized to sulphur trioxide, especially in the presence of metal particulates, and the sulphur trioxide reacts with water to form sulphuric acid. Acid rain is a combination of sulphuric acid and nitric acid formed from the nitrogen oxides. It is the hydrogen ion component of acid rain that is toxic, and affects cell membranes, acidifies the substrata, and leaches metals such as calcium from the lichen (Richardson 2008).

Despite declines in acid deposition in eastern Canada, large areas continue to receive levels of acid deposition in excess of critical loads. Exceedances of critical loads are greater for New Brunswick and Nova Scotia than Newfoundland. Predicted declines in SO2 and NOx for eastern Canada and the US may help reduce negative impacts on habitat quality for *E. mollissimum*. However, proposed industrial developments for New Brunswick, Nova Scotia and Newfoundland may have the opposite effect and could potentially cause a reduction in local *E. mollissimum* populations. In Nova Scotia, a gold processing facility is proposed for Moose River, less than 8 km from one *E. mollissimum* occurrence. In Newfoundland, an oil refinery and nickel processing facilities are proposed for the Avalon, 60 and 23 km from *E. mollissimum* occurrences respectively. A major expansion of the oil refinery in Saint John, New Brunswick is currently in the design phase (Canadian Press 2008). The expanded refinery could process up to 300,000 barrels of crude oil a day and would affect habitat quality for *E. mollissimum* in the Bay of Fundy.

Fog

Preliminary analyses of fog frequency along the Atlantic coast of Nova Scotia and the Avalon Peninsula of southeastern Newfoundland suggest that a significant decline has occurred over the past several decades (Beauchamp *et al.* 1998, Muraca *et al.* 2001). *Erioderma mollissimum*, like *E. pedicellatum, Cavernularia hultenii* (Maass 1981) and several other lichens occurring mainly in coastal fog forests, is probably a very drought-sensitive species. If the reported declines in fog frequency are confirmed by further research, these species could be negatively affected.

Moose browsing

Moose, an introduced species on the island of Newfoundland, are decreasing the available habitat for *E. mollissimum*. Moose were first introduced to the island of Newfoundland in 1878 and later in 1904. With extirpation of wolves from the island, the moose population quickly expanded. Today moose densities are high (McLaren *et al.* 2004). Moose preferentially browse birch and fir (preferred phorophyte of *E. mollissimum*) often limiting their re-establishment in tree harvest and naturally disturbed areas (Bergerud and Manuel 1968). Areas of heavy moose browse have become so extensive, foresters and ecologists have become concerned about the future of Balsam Fir as a major component of forests. As Balsam Fir is the only known substrate for *E. mollissimum* in Newfoundland, loss or decline in amount of Balsam Fir will have serious negative impacts on *E. mollissimum.*

Forestry

Forest cutting is also decreasing the available habitat for *E. mollissimum*. This threat is greatest in Nova Scotia where harvest levels have exceeded or met sustainable harvest levels in the last 10 years. As a result, less and less area of mature and overmature forest remains available for *E. mollissimum*. For example, in 1958, 25% of Nova Scotia's forests were over 80 years of age but this percentage has declined to just 1% at the present time (Pannozzo and Colman 2008).

The area with the largest known population of *E. mollissimum* in Newfoundland is scheduled for harvesting. Effectiveness of proposed buffers for protecting *E. mollissimum* in harvest areas are uncertain. Buffers of 20 or 30 m for *E. pedicellatum* have shown mixed success in maintaining this species (Cameron and Neily 2007). Rheault *et al.* (2003) in Canada, and Esseen and Renhorn (1998) in Sweden, found edge effects on fruticose lichens as far as 50 m into the forest from a cut edge.

High levels of human activities within the landscape may also affect habitat quality for *E. mollissimum*. Activities such as road building and clearcutting can affect micro-climates of nearby forests. For example, roads can affect hydrology by intercepting rainfall, concentrating waterflow and diverting natural water drainage (Cameron 2006). This in turn can affect the wetlands on which *E. mollissimum* depend. High levels of harvesting in a landscape can increase wind and drying effects in adjacent forests (Hunter 1990). Dependence on high levels of moisture by *E. mollissimum* makes it particularly susceptible to disturbance.

Coastal development

Another threat to *E. mollissimum* may be loss of forest area to other land uses. For example, the Newfoundland and Labrador Department of Natural Resources (Anon. 2006) estimates a conversion rate of forest to other uses (cottages, agriculture, residential, roadways and other) to be about 1,200 ha per 5 years in the Avalon Peninsula. They predict this trend will increase in the next few years. Coastal development in Nova Scotia and New Brunswick continue to occur but no data appear to be available on the rate of forest loss. The Halifax Regional Municipality is the fastest growing community in Nova Scotia and the number of new subdivisions has more than doubled from 429 in 1998 to 883 in 2005. Cameron *et al.* (2007) estimate this amounts to about 700 to 5000 ha of forest loss.

Associated with coastal development is tourism, which can increase human traffic, motor vehicles and loss of habitat from developments such as roads, trails, parking lots and other facilities. An example of this kind of impact in areas where *E. mollissimum* can occur is the Fundy Trail Parkway which has resulted in 16 km of trail, 11 km of highway and 400,000 visitors since 1998 (New Brunswick Tourism and Parks 2006).

PROTECTION, STATUS AND RANKS

Legal protection and status

Erioderma mollissimum has not received legal status within any jurisdiction in Canada.

The Thomas Raddall occurrence in Nova Scotia is within a provincial park and is fully protected from human development or harvesting but may be exposed to the effects of long-distance air pollution. All other occurrences for *E. mollissimum* in Nova Scotia are within areas not currently legally protected in perpetuity.

Non-legal status and ranks

E. mollissimum has been assigned a red status by the Province of Nova Scotia, May be at Risk in New Brunswick and S1 by the Atlantic Canada Conservation Data Centre and has G-rank of G4G5. See section Habitat Protection/Ownership for details on habitat protection.

Habitat protection and ownership

The Blandford occurrence is owned by the Nature Conservancy of Canada and will be set aside for protection of biodiversity. Two occurrences on Crown land, Webber Lake and Dooks Pond, are within the Ship Harbour Long Lake Candidate Wilderness Area. It is likely these two *E. mollissimum* occurrences will be part of the proposed designation in 2009. Clyde River Road1 and Bon Mature Lake are on Crown land. Three occurrences, Fuller Lake, Otter Pond and Martin Brook, are owned by forestry companies. The remaining 10 occurrences in Nova Scotia are owned by private landowners. All verified *E. mollissimum* occurrences in Newfoundland are on Crown land.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Robert Cameron has been studying lichens for over ten years beginning with a Masters degree in Biology at Acadia University studying the effects of forestry practices on lichens. More recently, Mr. Cameron has been studying the effects of air pollution on lichens, coastal forest cyanolichens and more specifically boreal felt lichen. Robert Cameron has a B.Sc.F. (wildlife biology) degree from University of New Brunswick. Mr. Cameron is currently the ecologist with Protected Areas Branch of Nova Scotia Environment and Labour, responsible for the protected areas research program.

Thomas Neily is a consulting botanist, with a botany degree from MacDonald college in Montreal. Mr. Neily has extensive experience in botanical field inventories including many lichen field studies. He has been studying rare cyanolichens in Nova Scotia for the last 3 years and has co-authored several scientific papers on this work.

Stephen Clayden is curator of botany and mycology at the New Brunswick Museum, where he established a collection of lichens now numbering > 15,000 specimens. He earned a Ph.D. in lichenology from the University of London for studies of the systematics and life histories of *Rhizocarpon* and an M.Sc. from the Université de Montréal, for research on post-fire succession in lichen communities on rock outcrops in northwestern Quebec. He has authored or co-authored 18 peer reviewed papers and numerous reports, including the COSEWIC status report on *Pseudevernia cladonia*. He also co-authored the COSEWIC report “Rare Lichens of Canada: a Review and Provisional Listing.

Wolfgang Maass, has been conducting botanical research for over 50 years. After obtaining a Ph.D. in 1957, he spent several years conducting research in Germany, including work at the Max Planck Institute. In 1960, Dr Maass emigrated to Canada where he began work at the National Research Council which included work on *Sphagnum* and lichens. He retired from NRC in 1986 but has continued his research on lichens since then. Dr Maas was senior author of the COSEWIC Status Report on *Erioderma pedicellatum*.

COLLECTIONS EXAMINED

All specimens collected and/or examined during the preparation of this report are listed in Appendix 1.

Appendix I. Summary of field work for status assessment for *Erioderma mollissimum* in 2007/08

Date	Area visited	Purpose of visit	*E. mollissimum* found?	Collections made	Photograph
8 Sept. 07	Halls Gullies, NL	Verify 3 possible occurrences	1 occurrence is confirmed presente, 2 occurrences are confirmed absente	S.R.Clayden NMB #1750, 1751	Yes
10 Sept. 07	Halls Gullies, NL	Verify 2 possible occurrences	2 occurrences confirmed presente		Yes
11 Sept. 07	Southeast Placentia, NL	Verify 1 possible occurrence	Occurrence confirmed		Yes
7 Oct. 07	Bear Lake	Verify 1 occurrence	Occurrence confirmed		Yes
9 Oct. 07	Otter Pond, Dooks Pond, Fuller Lake, NS	Verify 3 possible occurrences	3 occurrences verified presente	Otter Pond	Yes
20 Oct. 07	Blandford, NS	Verify 1 possible occurrence	Occurrence confirmed		Yes
28 Oct. 07	Lake John Road, NS	Verify 2 possible occurrences	2 occurrences confirmed		Yes
8 Nov. 07	Clyde River Road 1 & 2	Discover two new occurrences			No
9 Nov. 07	Martin Brook	Discover new occurrence			No
15 Nov. 07	Webber Lake, NS	Verify 1 possible occurrence	Occurrence confirmed		Yes
28 Nov. 07	Canada Hill 1&2	Discover two new occurrences			No
7 Dec. 07	Bon Mature Lake	Discover new occurrence			No
18 Dec. 07	Robarts Pond	Discover new occurrence			No
7 Jan. 08	Glenwood	Verify 1 past occurrence	Confirmed absente		No
9 Jan. 08	Haley Lake	Discover new occurrence			Yes
31 Jan.08	Thomas Raddall & Port L'Hebert	Discover two new occurrences			No
12 Mar. 08	Jones Harbour	Discover new occurrence		Collected small lobes of fertile thalli	Yes

Appendix II. *Erioderma mollissimum* thalli maturity class, width and height measurements for 13 occurrences in Atlantic Canada. Width was measured as longest horizontal distance and height was measured as longest vertical distance. Life stages have been simplified for presentation in the table.

Occurrence	Province	Immature		Mature		Fracture-Immature		Fracture-Mature	
		width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)
Bear Lake	NS			1.85	0.6				
	NS							0.25	0.3
	NS			5.11	3.3				
Fuller Lake	NS			1.42	1.48				
	NS			2.44	1.55				
	NS	0.24	0.22						
	NS	0.34	0.39						
	NS	0.49	0.5						
	NS			1.5	1.04				
	NS					0.51	0.56		
	NS					0.39	0.14		
	NS							0.74	0.3
	NS							0.92	0.75
	NS					0.51	0.55		
	NS					0.7	0.74		
	NS					0.37	0.3		
	NS			2.1	2.9				
	NS			0.79	0.49				
	NS			0.63	0.4				
Otter Pond	NS			3.35	2.51				
	NS			1.51	2.06				
	NS			1.47	1.15				
	NS	0.37	0.38						
	NS			0.7	0.6				
	NS			1.53	1.01				
	NS			0.61	1.24				
Dooks Pond	NS			5.73	2.12				
	NS			2.49	2.76				
	NS			4.95	3.64				
	NS			5.61	1.91				
Halls Gullies2	NL							1.2	1.2
	NL							1.8	3.2
	NL					0.3	0.2		
	NL					1.6	1.5		
	NL							5.8	7
	NL							3	4
	NL							1.9	1.7
	NL	0.6	1.1						
	NL							1.4	1.4
	NL							0.8	0.9

Occurrence	Province	Immature		Mature		Fracture-Immature		Fracture-Mature	
		width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)
Halls Gullies3	NL			6.2	2.8				
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL					<0.1	<0.1		
	NL			1.3	1.9				
	NL	1.4	1.4						
SE Placentia	NL			4.2	38				
	NL			3.8	7.2				
Blandford	NS			7.7	7.4				
	NS			6.9	4.8				
	NS			3	2.1				
	NS			4.9	4.4				
Lake John Road1	NS			33.9	41.1				
	NS			42.9	80.4				

Occurrence	Province	Immature		Mature		Fracture-Immature		Fracture-Mature	
		width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)
Lake John Road2	NS			30.5	30.7				
	NS			14.3	11.1				
	NS	9.5	7.4						
	NS			8.8	8.2				
	NS	6.4	5.8						
	NS			28.2	21.8				
	NS			16.5	13.1				
	NS			55.7	59.9				
	NS			51.1	33.8				
	NS			15.4	7.6				
	NS			11.7	11				
	NS			41.4	37.9				
	NS			28	20.4				
	NS			27.3	23.5				
	NS			20.1	17.7				
	NS			46.3	24.9				
	NS			38.4	73.9				
	NS			12.3	12.3				
	NS			20.1	27.7				
	NS			34.6	36.5				
	NS			15.1	18.3				
	NS			34.3	40				
	NS			36.9	34.6				
	NS			50.2	45.6				
Webber Lake	NS			2	2.1				
	NS			21.5	12.6				
	NS			2.3	1.4				
	NS			3	2.8				
	NS			6	4.5				
	NS			8	4.5				
	NS			5	3				
Thomas Raddall Tree 1	NS			9.25	9.29				
	NS			11	9.5				
	NS							10	10

Occurrence	Province	Immature		Mature		Fracture-Immature		Fracture-Mature	
		width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)
Thomas Raddall Tree 2	NS			1.9	1.4				
	NS			1.59	1.05				
	NS			2.67	1.42				
	NS			2.9	3				
	NS			5.6	4.4				
	NS			2.4	3.13				
	NS			2.51	2.82				
	NS	2.49	2.2						
	NS	0.85	0.9						
	NS			2.3	1.7				
	NS			2.6	2.7				
	NS			1.9	1.8				
	NS	0.69	0.7						
	NS	1	0.83						
	NS			2.1	1.9				
	NS			3.15	3.25				
	NS	0.8	1						
	NS							15	6
	NS							10	6
Thomas Raddall Tree 3	NS	1.1	1						
	NS			3.2	4.12				
	NS			5.58	2.36				
Thomas Raddall Tree 4	NS	0.6	0.6						
	NS							2.55	4.56
	NS			3.2	3.9				
	NS							4.4	7.1
	NS	0.7	0.9						
Thomas Raddall Tree 5	NS			1.32	1.2				
	NS			12.52	12.88				
	NS	0.9	0.7						
Thomas Raddall Tree 6	NS								
	NS								
Thomas Raddall Tree 7	NS			7.36	7.05				
	NS			2.55	1.9				
	NS			5.5	3.7				
	NS			3.65	3.5				
	NS			3.4	4.45				
	NS			8.8	13.4				
	NS			6.3	5.65				

Appendix III. Phorophyte parameters and position of *Erioderma mollissimum* on phorophyte for 13 occurrences in Atlantic Canada. Dashes indicate data was not collected.

Occurrence	Province	Height of thallus on tree (m)	DBH of tree (cm)	Orientation of thallus on tree		Tree species
				degrees	cardinal	
Bear Lake	NS	0.86	-	340	nw	Balsam Fir
	NS	0.86	-	340	nw	Balsam Fir
Fuller Lake	NS	1.42	19.7	341	nw	Yellow Birch
	NS	1.35	19.7	341	nw	Yellow Birch
	NS	138	19.7	341	nw	Yellow Birch
	NS	1.4	19.7	341	nw	Yellow Birch
	NS	1.398	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	341	nw	Yellow Birch
	NS	1.44	19.7	341	nw	Yellow Birch
	NS	1.41	19.7	51	ne	Yellow Birch
	NS	1.42	19.7	51	ne	Yellow Birch
Otter Pond	NS	1.19	16.1	23	ne	Yellow Birch
	NS	1.2	16.1	41	ne	Yellow Birch
	NS	1.16	16.1	48	ne	Yellow Birch
	NS	1.19	16.1	51	ne	Yellow Birch
	NS	1.19	16.1	66	ne	Yellow Birch
	NS	1.14	16.1	66	ne	Yellow Birch
	NS	1.14	16.1	35	ne	Yellow Birch
Dooks Pond	NS	1.52	29.5	324	nw	Yellow Birch
	NS	1.55	29.5	324	nw	Yellow Birch
	NS	1.54	29.5	349	nw	Yellow Birch
	NS	1.62	29.5	324	nw	Yellow Birch
Halls Gullies2	NL	0.8	9.3	325	nw	Balsam Fir
	NL	0.87	9.3	25	ne	Balsam Fir
	NL	0.88	9.3	50	ne	Balsam Fir
	NL	0.892	9.3	50	ne	Balsam Fir
	NL	0.97	9.3	77	ne	Balsam Fir
	NL	1.03	9.3	135	se	Balsam Fir
	NL	0.94	9.3	193	s	Balsam Fir
	NL	0.65	9.3	135	se	Balsam Fir
	NL	0.73	9.3	135	se	Balsam Fir

Occurrence	Province	Height of thallus on tree (m)	DBH of tree (cm)	Orientation of thallus on tree		Tree species
				degrees	cardinal	
Halls Gullies3	NL	1.64	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	1.6	-	120	se	Balsam Fir
	NL	2	-	64	ne	Balsam Fir
	NL	1	-	184	s	Balsam Fir
SE Placentia	NL	1.88	7.5	80	ne	Balsam Fir
	NL	-	10.9	3	n	Balsam Fir
Blandford	NS	2.51	13.4	284	w	Red Maple
	NS	2.58	13.4	284	w	Red Maple
	NS	2.63	13.4	284	w	Red Maple
	NS	2.67	13.4	259	w	Red Maple
Lake John Road1	NS	1.8	23.5	317	nw	Red Maple
	NS	2.3	23.5	345	nw	Red Maple
Lake John Road2	NS	0.8	11.7	326	nw	Red Maple
	NS	1.05	11.7	38	ne	Red Maple
	NS	1.21	11.7	81	ne	Red Maple
	NS	1.2	11.7	28	ne	Red Maple
	NS	1.29	11.7	28	ne	Red Maple
	NS	1.16	11.7	310	nw	Red Maple
	NS	1.38	11.7	118	se	Red Maple
	NS	1.36	11.7	53	ne	Red Maple
	NS	1.38	11.7	343	nw	Red Maple
	NS	1.41	11.7	268	w	Red Maple
	NS	1.41	11.7	268	w	Red Maple
	NS	1.42	11.7	91	e	Red Maple
	NS	1.43	11.7	327	nw	Red Maple
	NS	1.58	11.7	335	nw	Red Maple
	NS	1.58	11.7	335	nw	Red Maple
	NS	1.59	11.7	251	sw	Red Maple
	NS	1.49	11.7	213	sw	Red Maple
	NS	1.58	11.7	156	se	Red Maple
	NS	1.63	11.7	98	e	Red Maple
	NS	1.69	11.7	103	e	Red Maple
	NS	1.71	11.7	25	ne	Red Maple
	NS	1.75	11.7	75	ne	Red Maple
	NS	1.85	11.7	129	se	Red Maple
	NS	1.89	11.7	129	se	Red Maple
Webber Lake	NS	1.6	-	331	nw	Red Maple
	NS	2.4	-	360	n	Red Maple
	NS	1.6	-	30	ne	Red Maple
	NS	1.8	-	30	ne	Red Maple
	NS	2	-	91	e	Red Maple
	NS	2	-	91	e	Red Maple
	NS	2.4	-	91	e	Red Maple

Occurrence	Province	Height of thallus on tree (m)	DBH of tree (cm)	Orientation of thallus on tree		Tree species
				degrees	cardinal	
Thomas Raddall Tree 1	NS	2.1	-	-	n	Balsam Fir
	NS	2.3	-	-	n	Balsam Fir
	NS	3	-	-	n	Balsam Fir
Thomas Raddall Tree 2	NS	1.1	-	-	ne	Red Maple
	NS	1.1	-	-	nw	Red Maple
	NS	1.1	-	-	nw	Red Maple
	NS	1.4	-	-	n	Red Maple
	NS	1.4	-	-	n	Red Maple
	NS	1.42	-	-	n	Red Maple
	NS	1.42	-	-	n	Red Maple
	NS	1.42	-	-	n	Red Maple
	NS	1.4	-	-	n	Red Maple
	NS	1.4	-	-	n	Red Maple
	NS	1.4	-	-	n	Red Maple
	NS	1.65	-	-	n	Red Maple
	NS	1.65	-	-	n	Red Maple
	NS	1.75	-	-	n	Red Maple
	NS	1.75	-	-	n	Red Maple
	NS	1.22	-	-	n	Red Maple
	NS	1.33	-	-	nw	Red Maple
	NS	2	-	-	nw	Red Maple
	NS	1	-	-	nw	Red Maple
Thomas Raddall Tree 3	NS	1.28	-	-	ne	Red Maple
	NS	1.3	-	-	ne	Red Maple
	NS	1.28	-	-	ne	Red Maple
Thomas Raddall Tree 4	NS	1.5	-	-	e	Red Maple
	NS	1.6	-	-	e	Red Maple
	NS	1.65	-	-	e	Red Maple
	NS	1.7	-	-	e	Red Maple
	NS	1.8	-	-	e	Red Maple
Thomas Raddall Tree 5	NS	1.27	-	-	n	Balsam Fir
	NS	1.3	-	-	n	Balsam Fir
	NS	1.18	-	-	n	Balsam Fir
Thomas Raddall Tree 6	NS	-	-	-	-	Red Maple
Thomas Raddall Tree 7	NS	0.3	-	-	n	Red Maple
	NS	0.32	-	-	nw	Red Maple
	NS	0.8	-	-	n	Red Maple
	NS	1.6	-	-	n	Red Maple
	NS	1.6	-	-	n	Red Maple
	NS	1.9	-	-	nw	Red Maple
	NS	1.9	-	-	nw	Red Maple

Appendix IV. Health and condition of thalli of *Erioderma mollissimum* at 13 occurrences in Atlantic Canada.

Occurrence	**Province**	**Health**	**Necrosis** (% of thalli)	**Grazing** (% of thalli)
Bear Lake	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
Fuller Lake	NS	Good	0	3
	NS	Good	15	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	5	0
	NS	Good	5	0
	NS	Good	0	0
Otter Pond	NS	Good	0	0
	NS	Good	0	2
	NS	Good	0	5
	NS	Good	0	0
	NS	Good	0	10
	NS	Good	0	20
	NS	hanging loose	30	10
Dooks Pond	NS	Good	0	0
	NS	Good	0	0
	NS	Good	25	0
	NS	Good	30	0
Halls Gullies2	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	dying?	50	0
	NL	Good	10	0
	NL	?	40	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0

Occurrence	Province	Health	**Necrosis** (% of thalli)	**Grazing** (% of thalli)
Halls Gullies3	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	Good	0	0
	NL	dead portions	25	0
	NL	50% dead	30	0
SE Placentia	NL	loose and hanging	30	0
	NL	necrotic parts are loose	80	0
Blandford	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
Lake John Road1	NS	Good	30	5
	NS	Good	0	0
Lake John Road2	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	5
	NS	Good	5	1
	NS	Good	0	0
	NS	hanging loose	50	20
	NS	dying	0	0
	NS	Good	5	0
	NS	Good	0	0
	NS	Poor	40	0
	NS	Poor	50	0
	NS	Poor	50	5
	NS	Good	30	0
	NS	Good	40	0
	NS	Good	0	0
	NS	Good	20	0
	NS	Good	25	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	10	0
	NS	Good	0	0
	NS	Okay	30	20
	NS	Good	0	0
	NS	Good	0	0
Webber Lake	NS	Good	0	0
	NS	Declining	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0
	NS	Good	0	0

Occurrence	Province	Health	**Necrosis** (% of thalli)	**Grazing** (% of thalli)
Thomas Raddall Tree 1	NS	Good	0	0
		Good	0	0
		Good	0	0
Thomas Raddall Tree 2		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good		10
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
Thomas Raddall Tree 3		Good	0	0
		Good	0	0
		Good	0	0
Thomas Raddall Tree 4		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
Thomas Raddall Tree 5		Good	0	0
		Good	0	0
		Good	0	0
Thomas Raddall Tree 7		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0
		Good	0	0

Appendix V. Forest structural variables at 13 occurrences of *Erioderma mollissimum* in Atlantic Canada.

Occurrence	**Province**	**Mean crown closure** (%)	**Mean age**	**Mean DBH** (cm)	**Mean Height** (m)	**Density** (trees/ha)
Dooks Pond	NS	98.50	67.33	14.70	9.00	8416.80
Bear Lake	NS	54.25	65.00	9.13	6.50	15116.90
Hall's Gullies 1	NL	56.67	56.33	9.33	8.33	6830.13
Hall's Gullies 2	NL	62.33	78.67	10.87	8.00	17777.78
Hall's Gullies 3	NL	61.80	70.00	10.84	7.40	3086.42
SE Placentia	NL	19.00	95.00	9.20	5.67	7561.44
Lake John Road1	NS	94.00	61.00	19.00	9.33	1319.11
Lake John Road 2	NS	84.50	72.33	16.90	6.33	2163.33
Fuller Lake	NS	14.25	45.33	13.33	6.67	23668.64
Otter Pond	NS	90.75	53.25	16.08	8.00	7346.94
Blandford	NS	66.00	99.00	14.80	11.67	5225.72
Webber Lake	NS	28.50	63.67	16.33	8.17	6103.52
Mean for all sites		61.21	68.48	13.20	7.81	1890.87
95% confidence Interval		11.83	6.60	1.43	0.80	1986.50

Appendix VI. Percent by basal area of tree species, dead trees and windthrown trees for 13 occurrences of *Erioderma mollissimum* in Atlantic Canada.

		Percent by basal area						
Occurrence	Province	Balsam Fir	Black Spruce	Red Maple	Yellow Birch	White Birch	Dead trees	Windthrow trees
Dooks Pond	NS	56	38	0	6	0	17	13
Bear Lake	NS	100	0	0	0	0	22	6
Hall's Gullies 1	NL	90	10	0	0	0	19	0
Hall's Gullies 2	NL	92	8.3	0	0	0	50	0
Hall's Gullies 3	NL	84	17	0	0	0	40	0
SE Placentia	NL	67	27	0	0	6	29	0
Lake John Road1	NS	47	0	53	0	0	25	0
Lake John Road 2	NS	27	7	67	0	0	12	0
Fuller Lake	NS	80	0	20	0	0	50	0
Otter Pond	NS	64	27	0	9	0	35	0
Blandford	NS	83	8	8	0	0	29	0
Webber Lake	NS	50	14	36	0	0	50	7

Appendix VII. Parameters for 13 occurrences of *Erioderma mollissimum* in Atlantic Canada. Dashes indicate data were not collected.

Occurrence	**Province**	**Slope** (%)	**Shrub cover** (%)	**Herb cover** (%)	**Sphagnum cover** (%)	**Other moss cover** (%)	**Aspect**	**Topographic position**	**Soil drainage**
Dooks Pond	NS	2	3	20	75	15	45	depression	poor
Bear Lake	NS	0	10	10	70	10	-	depression	poor
Hall's Gullies 1	NL	6	0	5	40	60	10	lower slope	imperfect
Hall's Gullies 2	NL	5	0	20	30	60	140	lower slope	-
Hall's Gullies 3	NL	6	15	15	40	60	190	upper slope	well
SE Placentia	NL	3	15	25	15	85	290	mid slope	well
Lake John Road1	NS	2	10	80	80	10	45	depression	imperfect
Lake John Road 2	NS	0	25	80	90	10	0	depression	imperfect
Fuller Lake	NS	0	10	70	80	10	0	depression	poor
Otter Pond	NS	0	10	10	85	5	0	depression	poor
Blandford	NS	0	5	90	85	5	0	depression	imperfect/poor
Webber Lake	NS	0	50	-	-	-	0	depression	saturated